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NASA

OSSA SUBORBITAL SCIENCE SOUNDING ROCKET PROGRAM

PROCEEDINGS OF WORKSHOP

VOLUME I

Crystal Gateway Marriott
Crystal City, Va
November 12-13, 1991

Office of Space Science and Applications

Workshop on

Suborbital Science Sounding Rocket Program

November 12-13, 1991

Proceedings of Workshop

Volume I

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WORKSHOP ON
THE SUBORBITAL SCIENCE SOUNDING ROCKET PROGRAM
NASA OFFICE OF SPACE SCIENCE AND APPLICATIONS
NOVEMBER 12-13, 1991

AGENDA

Tuesday 12 November

REGISTRATION	7.30 a.m.
INTRODUCTION - OPENING REMARKS (T. Perry)	8.00 a.m.
OSSA PERSPECTIVE (J. Alexander)	8.15 a.m.
THE OSSA SCIENCE SOUNDING ROCKET PROGRAM	8.30 a.m.
• Characteristics of Program (T. Perry)	
• Science Community Interface (W. Neupert)	
• Investigator Perspectives (M. Mendillo)	
BREAK - Refreshments served	10.00 a.m.
• Current Project Implementation/Operations (W. Gurkin)	10.15 a.m.
• Wallops Flight Facility (R. Stanley)	
KEY ISSUES & NASA CONCERNS (T. Perry/L.Evey)	11.30 a.m.
• Oversight/Licensing	
• Safety and Reliability	
• Insurance	
• Financing	
• Procurement	
• Legislative	
LUNCH - at leisure	12.00 noon
FACILITY PRESENTATIONS	
White Sands Missile Range (Cmdr. K. Watterson)	1.00 p.m
Virginia Center for Innovative Technology (S. Morgan)	1.40 p.m.
Florida Spaceport Authority (J. Ralph)	2.20 p.m.
BREAK - Refreshments served	3.00 p.m.
INDUSTRY PRESENTATIONS	
Bristol Aerospace (B. Habbington)	3.15 p.m.
Orbital Sciences (S. Webster/T. Lewis)	3.55 p.m.
AmRoc (B. Hughes)	4.35 p.m.
ADJOURNMENT REMARKS (T. Perry)	5.05 p.m.

WORKSHOP ON
THE SUBORBITAL SCIENCE SOUNDING ROCKET PROGRAM
NASA OFFICE OF SPACE SCIENCE AND APPLICATIONS
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AGENDA (cont.)

Wednesday 13 November

OPENING REMARKS (T. Perry)	8.00 a.m.
INDUSTRY PRESENTATIONS (cont.)	
EER Systems (J. Koletty)	8.05 a.m.
Space Industries Inc. (O. Smistad)	8.45 a.m.
British Aerospace (J. Ellis)	9.25 a.m.
BREAK - Refreshments served	10.05 a.m.
Conatec, Inc. (W. H. Montag)	10.30 a.m.
SpaceTech (J. Williams)	11.10 a.m.
LUNCH - at leisure	11.50 a.m.
Space Vector Group (J. Jerger)	1.00 p.m.
Teledyne Brown (T. Sharpe)	1.40 p.m.
(REFRESHMENTS AVAILABLE FROM 1.30 p.m. - NO BREAK)	
Johnson & Higgins (A. Deering)	2.20 p.m.
CLOSING REMARKS (T. Perry) • Follow-on activities/Further meetings	3.00 p.m.

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Chairman's Summary of Discussion

A total of 91 representatives from 31 launch vehicle, launch services, payload integration companies participated in the workshop. The first two items on the agenda were switched, and the final presentation was deleted as Ms. Deering was unable to attend.

The workshop was opened by Mr. Tom W. Perry, Deputy Director, Space Physics Division, Office of Space Science and Applications (OSSA). The Space Physics Division manages the Suborbital Science Sounding Rocket Program on behalf of OSSA.

He expressed some concern as to the viability of any "commercial market" for sounding rockets, and referred to existing government-sponsored efforts to develop such a market through the NASA Office of Commercial Programs. He said he hoped the workshop would shed some light on the topic, and looked forward to a two-way exchange of views over the course of the two days.

He gave the opening presentation and described unique characteristics of the sounding rocket program, stressing its importance to space science, for example, in providing UARS correlative measurements. The program offered significant educational benefits that NASA was determined not to lose. Other features included flexibility, fast response to investigator needs, widespread geographic distribution, and the use of surplus motors from stock. Special emphasis was placed on the mission success rate and excellent reliability record achieved over a period of many years, compared with apparent reliabilities of 50-75% in the commercial arena. Perry pointed out that the program had a budget of about $30 million a year, not including payload investment.

Mr. Joe Alexander, Assistant Associate Administrator (Science and Applications) described the sounding rocket program as critical to the success of the OSSA science program as a whole. He made three main points:

- that the program provided opportunities to do first class, innovative scientific studies in regions not other wise accessible
- that it was a testbed for developing new technologies, people and skills, giving graduate students unique hands-on experience, and experimental results, within the normal thesis period,
- that its key attributes were flexibility, reliability, and economy.

Alexander looked forward to enlarging and enhancing relationships between NASA, universities, and the private sector to win new kinds of help from the private sector while retaining the attributes described above.

Dr. Werner Neupert described the interface between NASA HQ, NASA Goddard Space Flight Center (GSFC), and the rocket Principal Investigators (PI). He described the proposal selection process, the cycle time to flight, constraints imposed by science objectives on operations, campaign modes, and coordination with ground-based facilities. There were questions about the success rate of proposals (about 3:1) and the primary sources of funding for the payloads (the Supporting Research and Technology (SR&T) Program from the branches of the science divisions in OSSA (primarily Space Physics, Astrophysics, Earth Sciences, and Solar System Exploration, and not Life Sciences or Microgravity Science). In response to one question, it was confirmed that there is essentially no non-NASA funding, although there may be some cooperative programs with other agencies.

Professor Michael Mendillo of Boston University gave a detailed presentation on PI requirements ranging from simple to complex payloads. He said that the program was very important to the US science community, and that there was already concern that its funding was under stress, impacting the number of missions flown, down from around 44 to 25 or so now. The program needed more help at NASA HQ. It had a high scientific yield, and he, speaking for other investigators, was very concerned about any potential "botch-up."

In the following discussion, Dr. David Reasoner (Acting Branch Chief, Ionospheric Branch, Space Physics Division) pointed out the increasing environmental concerns the program had to deal with, a comment seconded by Cmdr. Kent Watterson, Test Officer at the White Sands Missile Range (WSMR). In response to a question about the role industry currently plays in the program, Perry said about 125 support contractors worked at Wallops Flight Facility (WFF), that there was a contractor support team at WSMR, and that a variety of equipment was procured competitively, in addition to the sole source procurement of some motors from Bristol Aerospace.

Mr. Warren Gurkin, WFF, described unique characteristics of program operations, the types of launches by site and discipline, payload range, variety of launch vehicle configurations used, and the trend towards larger, more expensive payloads, such as those flown on the Aries. He costed total launch vehicle support at about $8 million a year. He described in particular the close working relationship necessary with the PI as payloads evolved and vehicle systems were integrated, and the flexibility gained through the lack of formal R&QA procedures. He discussed campaign and salvo modes of operation, often at foreign ranges. He said that some 55 projects were in process at any one time, each with a NASA manager responsible for directing the effort. All these NASA managers report to Gurkin.

Questioned about interfaces with Department of Defense (DoD), he said that there was no formal tie, although WFF worked with DoD, there was an arm's length relationship. Some PIs came from DoD laboratories, but pursued

scientific investigations. Asked about the reduced number of launches, Gurkin ascribed it to the levels of funding for science and for program support. More complex science was more expensive. Asked about the number of launch sites and whether the program planned continued mobile launches, Gurkin confirmed that but said WFF was not using as many sites as previously.

In response to a series of other questions, it was also said:
a) that launch vehicle assembly at WSMR was 100% contractor work, and that there was daily contact between WSMR contractors and the NASA manager
b) that it was usually about a year from proposal approval to flight, consistent with the 3-year grant process
c) that WFF experienced a reject rate of less than 5% on surplus motors (usually on Nike, the oldest)
d) that about 15 or 20 new Black Brants were purchased every few years
e) that surplus START motors were generally too big to use, and
f) that the balance between PI payload construction and PI contractors constructing the payload was mixed. Many support systems are provided by WFF.

In response to another question on environmental concerns, Perry described it as a serious issue, citing the Kwajalein experience.

Ray Stanley, WFF, described the facility and equipment at WFF (see brochure in the Presentations section). He described the required agreements with NASA HQ and subagreements with GSFC, both in place and pending for commercial entities to use government facilities, and said they take a long time to put in place. Cmdr. Watterson added that agreements with ranges were also necessary.

Lee Evey, NASA HQ, discussed NASA's efforts towards more commercial procurement procedures. He emphasized that he was looking at the past efforts, and that no current solicitation is in preparation. He made several main points. NASA:
a) looks for a highly reliable launch service
b) is not looking for the lowest bidder
c) will, to the maximum extent possible, write a procurement to allow everyone to compete
d) will not tell industry how to do a job, but will evaluate companies' own Q&A procedures
e) will not expect <u>certification</u> of cost/pricing data, but <u>will ask</u> for cost/pricing data - need to understand the difference

He stressed the evaluation factors in any solicitation, and characterized NASA's approach as "oversight and insight."

Perry closed the morning session by describing the legislative background encouraging NASA to undertake an assessment of the possibilities of increased commercial involvement in the program, and urged participants to help define some of the ideas surrounding the issue.

After lunch, Cmdr. Kent Watterson (WSMR) described the range, the "largest overland range in the country." He said many facilities were in need of upgrades, but the range is used by DoD, NASA, and commercial companies. There was a discussion of what constitutes a "commercial launch" described as one where the following paperwork is in place: Memorandum of Agreement (MOA) with the Navy; Department of Transportation (DoT) license; insurance; NASA agreements (for NASA facilities); all Range paperwork. Asked whether the Amendments to the Commercial Space Launch Act had not simplified these requirements, he said it had not happened so far.

In addition, Hazard Electromagnetic Radiation to Ordnance (HERO) certifications were necessary for equipment, and certified personnel had to be used. There were strict mil. spec. standards for Flight Terminations Systems, and also certain environmental requirements, depending on the impact expected. A Master Planning Board had to approve all facility modifications, such as bringing in a portable trailer.

Mr. Stephen Morgan, Virginia Center for Innovative Technology (CIT), described the work of CIT in facilitating industrial development and reducing impediments to commercial success. CIT has been active in helping get NASA agreements in place for the use of WFF. CIT is reviewing the law surrounding the use of WFF, with proposals for an enterprise zone, or a foreign trade zone. A new "Center for Commercial Space Infrastructure" has been established at Old Dominion University in Norfolk. Asked what impediments to success exist, Morgan said that people had difficulty identifying the market for these types of launch vehicles. "Lots of good rockets are looking for a payload." Payloads were also looking for rides, but the costs may be prohibitive. He cited assisting with regulatory approvals to launch from a government facility. He also mentioned that some firms do not want inspections of payloads, as they may be proprietary (particularly in the life sciences).

Mr. James Ralph, describing the Spaceport Florida Authority, said that Morgan had been its first President. He said that facilities at Kennedy Space Center (KSC) also needed upgrading and that a nascent partnership of government, contractors, and states had submitted a $20 million proposal to DoT, featuring a concept for an Advanced Launch Control Center.

He said there was a particular emphasis on education and training in the Charter of the Authority, and much had been achieved with local universities, e.g.

facilities were available to do environmental testing for rockets, for the universities. The Authority had mounted a mobile launch in Mexico in collaboration with FIT, to study the solar eclipse. The first launch from Cape San Blas, with an FSU meteorological payload, was scheduled for December 1991. Asked whether there was really a commercial market "out there", he said the Authority was interested in commercialization (e.g. use of zero gravity) but there had not been much interest.

Dave O'Connor, Bristol Aerospace, described corporate capabilities, organization, and overall sales before focussing on the Black Brant supplied to WFF. NASA is the biggest user, and all other customers are governments or agencies of government. Since 1985, Bristol has had only one serious inquiry from a commercial customer. O'Connor also described some orbital capability for small and micro satellites.

Tim Lewis, Space Data Division, Orbital Sciences Corporation (OSC), also described corporate capabilities, organization, and overall sales. Space Data had been in business for 26 years, OSC for 10 years. The third Pegasus flight will take place in 1992. OSC has the contract to provide NASA with space data from the SeaStar satellite. Lewis said they had flown 540 flights with a 98% success rate or 3,500 flights with a 93% success rate if the smallest DoD rockets were included. He said that he did not believe there was a viable commercial market, but there could be. More launches should be put into university hands for training programs, and there should be sponsored use of existing assets. Asked about sales, Lewis said that close to 80% was to DoD. OSC also has two contracts with NASA in the Joust Program run by the Office of Commercial Programs.

Brian Hughes, AmRoc, discussed the capabilities and advantages of the Hybrid rocket and described the HyFlyer Sounding Rocket which provides 11 minutes of microgravity for a Joust-class payload. The 72" diameter booster has a large payload capacity and can lift 8 tons. Hughes said it will be available in late 1993 with an estimated launch cost of $3.5 million. The company, he said, does not intend to go into the sounding rocket business. This is a demonstration of the propulsion system towards development of an orbital vehicle.

The workshop adjourned at approximately 5.30 pm on Tuesday 12 November and reconvened at 8.00 am on Wednesday 13 November.

The first speaker was Jack Koletty of EER Systems. He provided an overview of corporate development and current capabilities. NASA is the company's primary customer, particularly GSFC. With the acquisition of Space Services Inc. the company decided to press ahead with launch services, and has Consort (suborbital) and COMET (orbit) contracts with NASA OCP. It achieved the first commercial (i.e. DoT licensed) launch. The company has launched 3 Consorts (one of which failed) and was scheduled to launch another on Saturday November 16. Koletty explained they were all financed by government grants. Asked by Perry about

NASA/industry partnerships, he said it was a step in the right direction but that "the responsibility remains with NASA."

Olav Smistad of Space Industries International Inc. described the orbital COMET Program in which the company is involved, together with EER Systems, under the auspices of NASA's OCP, primarily for life sciences applications. The company does not work with sounding rockets.

John Ellis of British Aerospace (BAe) gave an overview of BAe, its products and capabilities and described the Skylark sounding rocket system, which he is interested in introducing to the American market. Since 1957, 422 rockets have been launched from ranges around the world, with a 98% motor reliability. Various configurations and performances were described, and compared to North American "equivalents." Sister organization, Royal Ordnance, described other liquid and solid propulsion systems.

Wayne Montag of Conatec described the company's capabilities and business base in launch services. He said that it had its "roots in the sounding rocket program," and therefore understood its philosophy and direction. Company personnel have extensive experience (10-30 years) in working with the sounding rocket program at WFF, and the company has worked on DoD suborbital programs and NASA OCP programs. Montag noted that the U.S. government (civil and military) constituted the major market for suborbital launches; that U.S. industry issues a few subcontracts in support of government programs; that opportunities to provide suborbital launch services have been limited; and that foreign requirements for such services have not been open to U.S. companies. Montag said that industry can work with OSSA and NASA WFF to maintain a successful suborbital science program. One suggestion was to include sounding rocket technologies in the NASA SBIR Program.

John Williams, of SpaceTech, described the AMTEX suborbital program for microgravity research based on the TEXUS payloads initiated by the German Ministry of Research. He described a market survey performed for NASA Code C on microgravity payloads, and provided details of an extensive series of German modules for such payloads. He described the company plans for an AMTEX-SR1 flight in 1993, with a currently selected payload and user selection underway. When asked how the company could select the payload before the user, he said that this enabled the company to price the mission and advise the user of his costs.

Joe Jergen of Space Vector described his $10 million business, mainly working with space control systems for DoD sounding rockets. NASA makes up about 15% of his business. The company has worked on 35 flights of the Sabre rocket with one failure, and now works with the Aries rocket flying AFGL experiments. Jergen is very enthusiastic about using the Minuteman II and III. He said that there are no commercial experiments because no-one can afford to get into space - Minuteman II launches would cost $6 million, rather than $12 million.

He challenged the audience to think more about the real goals of space commercialization. Space business should be established by the customer buying the product on the satellite, not the satellite or booster themselves. NASA should be directed to support certain missions in this way, and provide the budget. There should be direct sponsorship of state-of-the art technologies, and a closer sharing of DoD assets and contractor base, and NASA should represent the leading edge of visionary technologies.

Tony Sharpe of Teledyne Brown described corporate participation in the NASA OCP Joust Program. The company has a large commitment to materials processing (for example, it is working on furnace technology for the Space Station Freedom) and is part of the CCDS at the University of Alabama, Huntsville. Funding for the program comes from NASA and the consortium members. Teledyne Brown contribution was estimated at some $50,000 a year in cash, together with large in-kind services. The first Joust launch, June 18, 1991, failed 15 seconds into flight. The next launch is tentatively scheduled for May 6, 1992. Sharpe presented a lengthy list of "Lessons Learned." He said that the commercial market provided opportunities for materials processing and that aggressive marketing could yield flights for development of new products such as batteries, film, electronic components, and materials.

The workshop closed at 3.00 pm.

Chairman's Conclusions

A number of common issues emerged from the discussion. All speakers who addressed the issue agreed that currently there are no commercial customers for sounding rockets or their payloads. All current launch support services requirements now come from NASA's Office of Commercial Programs or the Department of Defense. Many speakers spoke of the need for further government sponsorship of commercial space efforts, and agreed that NASA needed to remain involved. No serious procurement impediments were identified.

In addition, there was no clear consensus on a proposed voucher system called for in draft legislation. There was no clear understanding of what a voucher system was or how it would work, and no consensus within the industry as to whether it would be beneficial or not. It was felt, however, that multiple rather than single launch procurements would be more advantageous to industry.

OSSA now intends to continue the dialogue it initiated at the workshop through a series of one-on-one meetings with industry representatives to discuss further a potentially enlarged role for the private sector in the OSSA Sounding Rocket Program.

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WORKSHOP ON THE SUBORBITAL SCIENCE

SOUNDING ROCKET PROGRAM

OFFICE OF SPACE SCIENCE AND APPLICATIONS

November 12–13, 1991
Crystal Gateway Marriott,
Crystal City

WORKSHOP ON THE SUBORBITAL SCIENCE SOUNDING ROCKET PROGRAM OFFICE OF SPACE SCIENCE AND APPLICATIONS

November 12–13, 1991
Crystal Gateway Marriott,
Crystal City

Objective: ".... to explore issues associated with possible increased commercial support of appropriate portions of the OSSA Suborbital Sounding Rocket Program.

Designed in two parts:

- **NASA will describe fully the objectives and current implementation of the OSSA Suborbital Sounding Rocket Program, and its unique features and requirements.**

- **Information from industry on its interest and potential capabilities in supporting sounding rocket science operations at NASA will be sought, by posing specific questions**

WORKSHOP AGENDA

OSSA PERSPECTIVE (J. Alexander)

THE OSSA SCIENCE SOUNDING ROCKET PROGRAM

- Characteristics of Program (T. Perry)
- Science Community Interface (W. Neupert)
- Investigator Perspectives (M. Mendillo)
- Current Project Implementation/Operations (L. Early)

KEY ISSUES & NASA CONCERNS (T. Perry)

- Oversight/Licensing
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FACILITY PRESENTATIONS

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WORKSHOP AGENDA (cont.)

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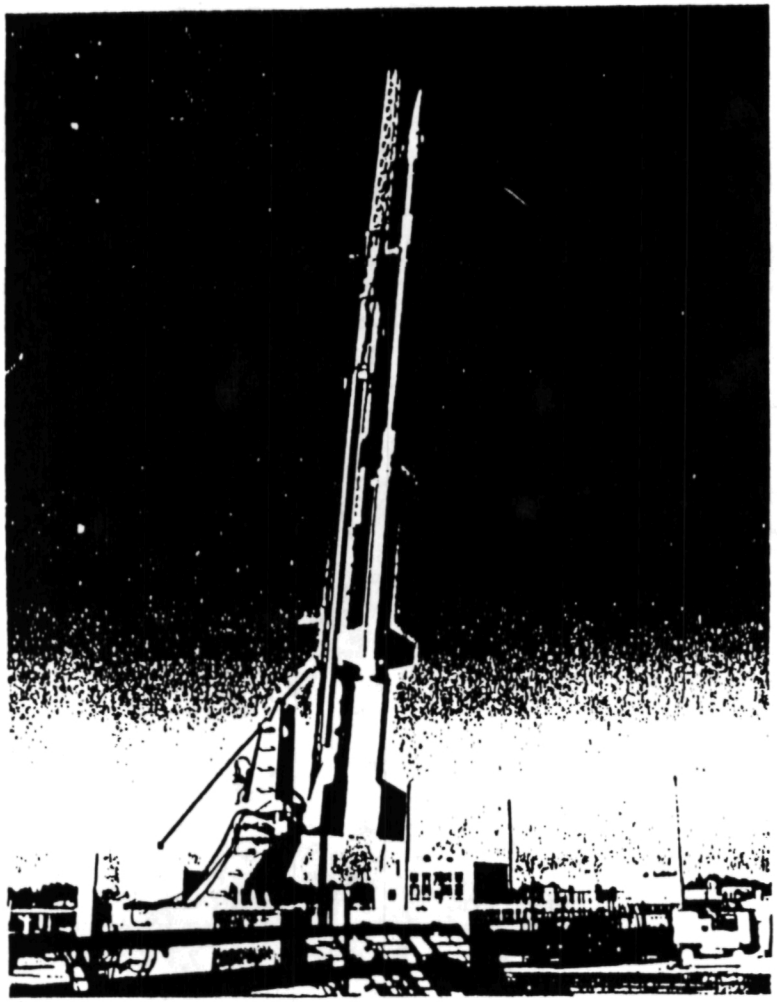
Florida Spaceport Authority	(Jim Ralph)
Bristol Aerospace	(Bret Habbington)
Orbital Sciences	(Scott Webster, Tim Lewis)
AmRoc	(Brian Hughes)
EER Systems	(Jack Koletty)
Space Industries Inc.	(Olav Smistad)
British Aerospace	(John Ellis)
Conatec, Inc.	(W. H. Montag)
SpaceTech	(John Williams)
Space Vector Group	(Joe Jerger)
Teledyne Brown	(Tony Sharpe)
Johnson & Higgins	(Ann Deering)

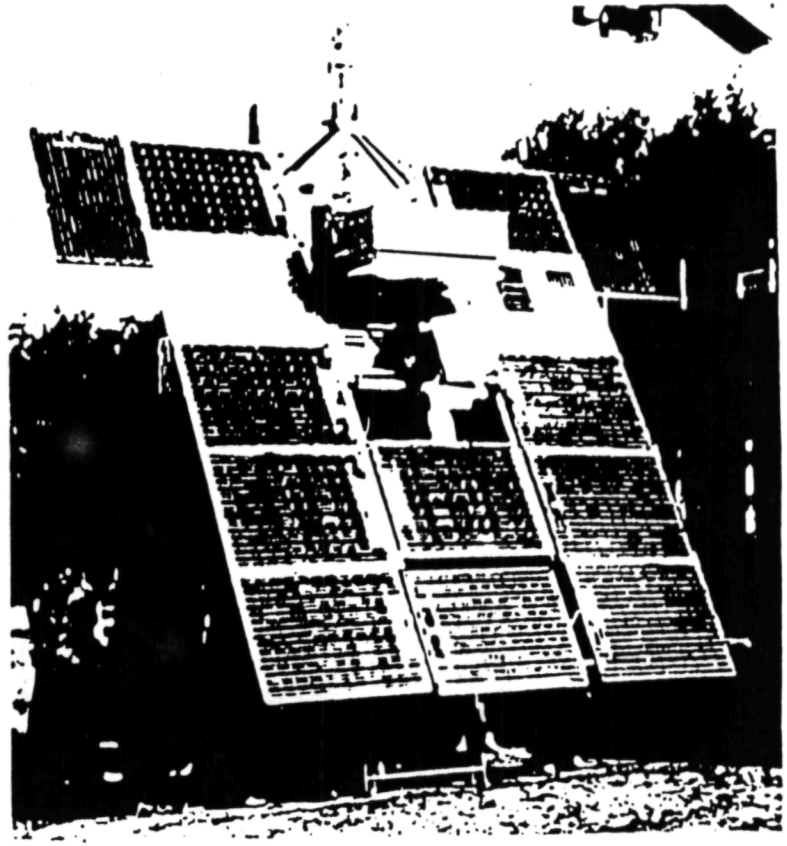
CLOSING REMARKS (T. Perry)

- Follow-on activities/Further meetings

Office of Space Science and Applications
Suborbital Program (Sounding Rockets)

Sounding Rockets





Office of Space Science and Applications
Suborbital Program (Sounding Rockets)

Four main goals characterize the Suborbital Program:

(1) the achievement of specific OSSA science objectives which are most effectively addressed by sounding rocket and balloon techniques,

(2) correlative measurements, "ground truth" and in situ calibration measurements made in support of longer duration spacecraft missions in order to verify and enhance the science return from those missions, and

(3) the development of new scientific instrument and sensor technology for eventual use on longer missions spacecraft.

(4) important societal benefits include graduate student researchers and international involvement.

Office of Space Science and Applications
Suborbital Program (Sounding Rockets)

The Suborbital Program supports research program elements of four OSSA Divisions:

Division	Sounding Rockets
Astrophysics	Ultraviolet & X-ray Astronomy
Earth Science & Applications	Upper Atmosphere Research
Solar System Exploration	Planetary Astronomy & Atmospheres Research
Space Physics	Solar, Mesosphere, Thermosphere, and Space Plasma Physics

Office of Space Science and Applications
Suborbital Program (Sounding Rockets)

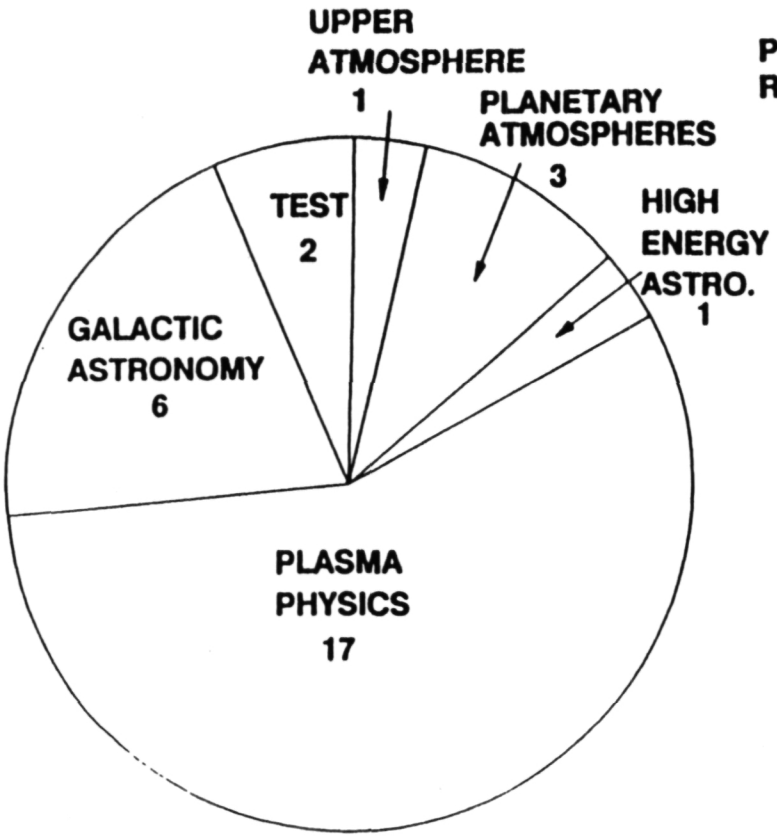
The Suborbital Program has been a major contributor to space science through its attributes of relatively low cost and quick response capabilities. A few of many examples:

- **Soft X-ray measurements of Sun during July 11, 1991 eclipse**
- **Comet Austin investigation four months after its discovery in December 1989**
- **Detection of gamma ray lines from isotopes produced via nucleosynthesis in Supernova 1987A**
- **Detection of X-ray emissions from Puppis A at unparalleled spatial and spectral resolution**
- **Sounding rocket observations of Comet Halley simultaneously with Giotto encounter**
- **Measurement of solar flux (50-1775 A) at the time of Voyager 2 Neptune encounter (for data interpretation)**

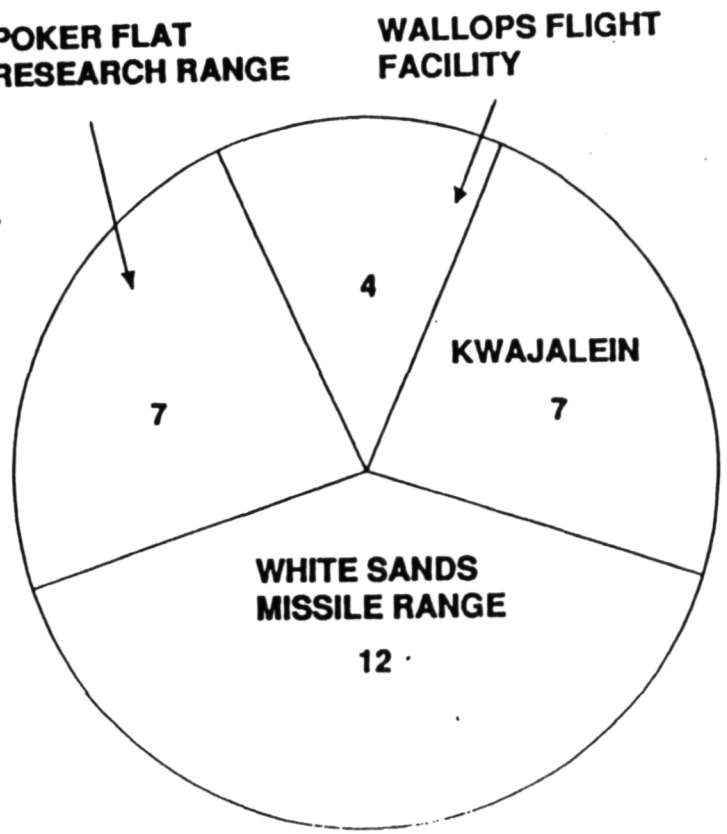
Office of Space Science and Applications
Suborbital Program (Sounding Rockets)

FY - 90 LAUNCHES - 30

BY DISCIPLINE



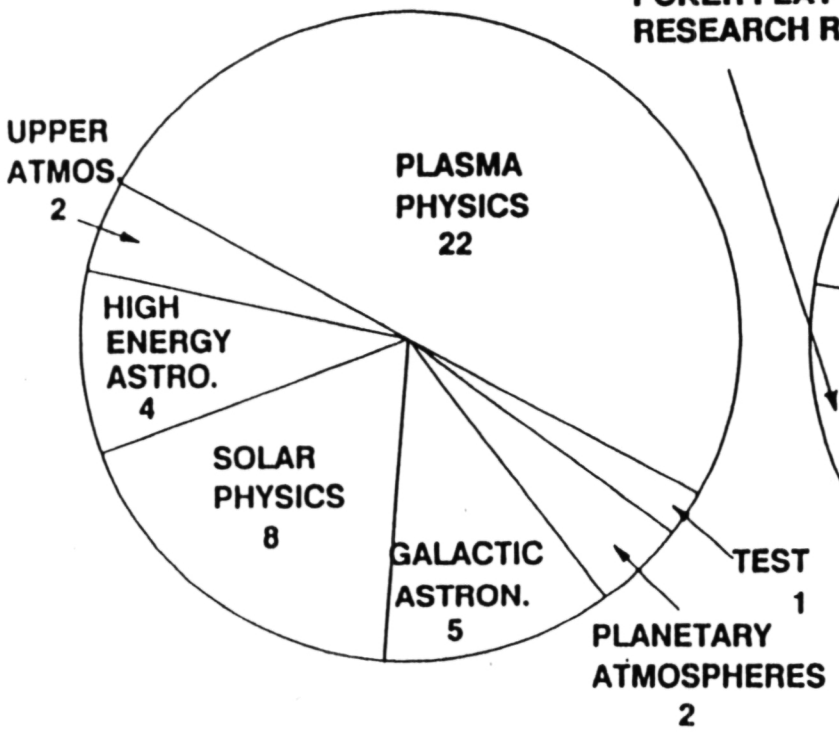
BY SITE



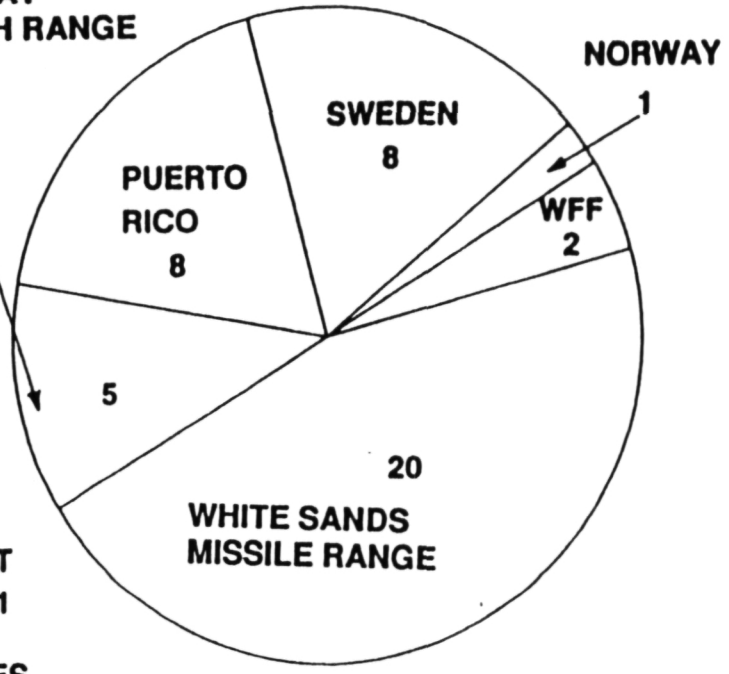
Office of Space Science and Applications
Suborbital Program (Sounding Rockets)

FY-91 LAUNCHES - 44 (CANDIDATE)

DISCIPLINE

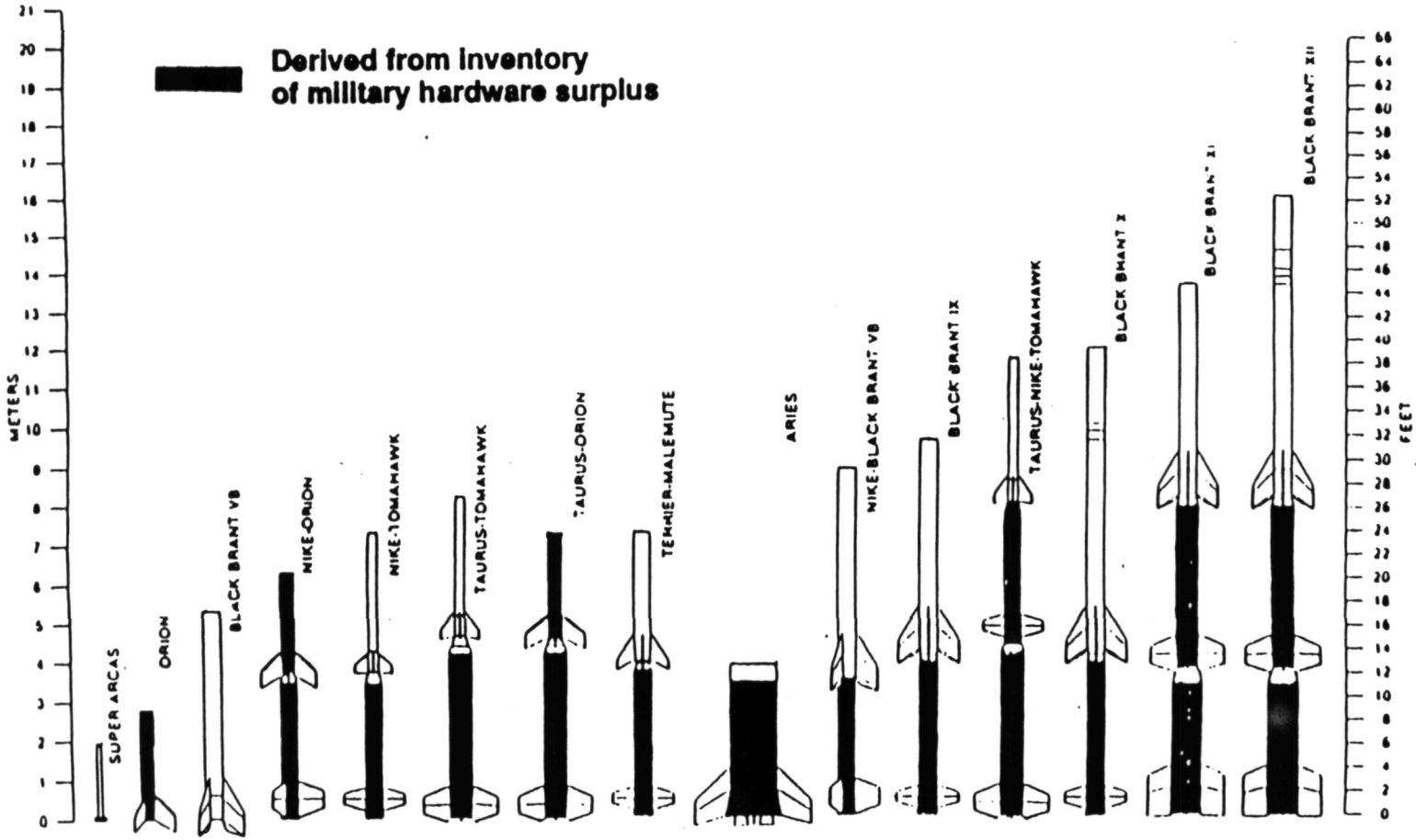


SITE

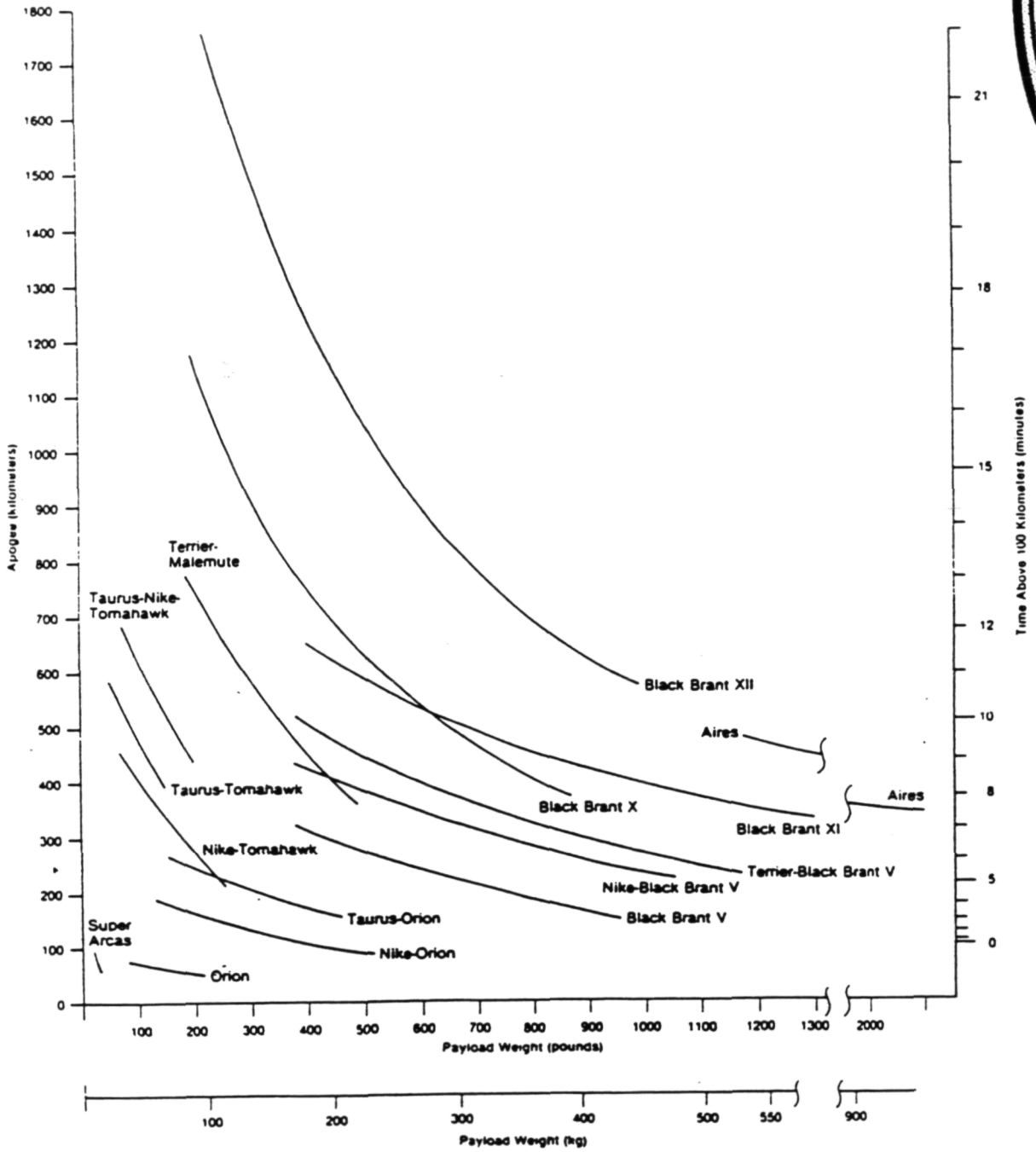


Office of Space Science and Applications
Suborbital Program (Sounding Rockets)

NASA SOUNDING ROCKETS

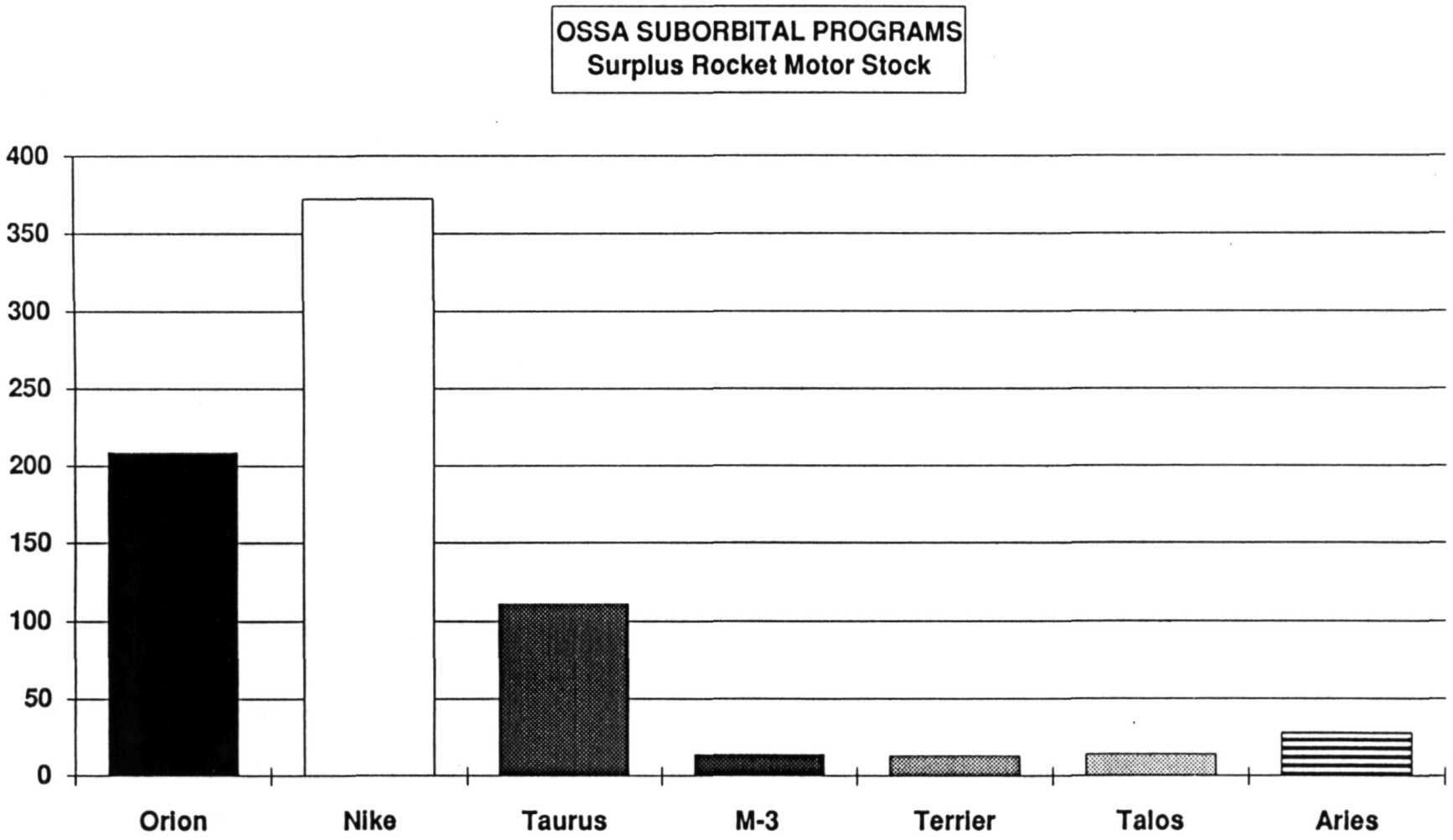


NASA Sounding Rocket Performance



Office of Space Science and Applications
Suborbital Program (Sounding Rockets)

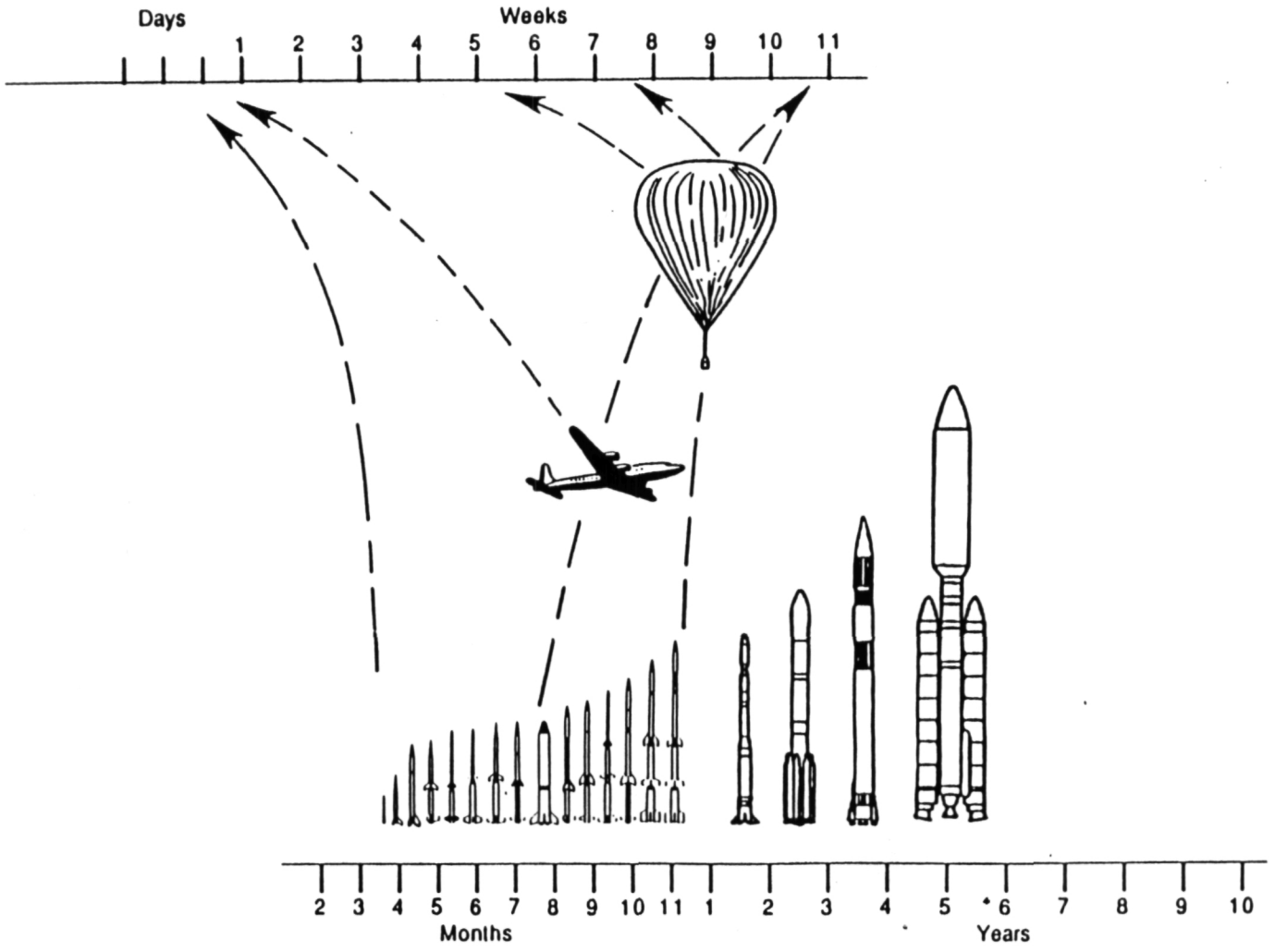
Office of Space Science and Applications
Suborbital Program (Sounding Rockets)



Office of Space Science and Applications
Suborbital Program (Sounding Rockets)

Flight Response Times

Response to New Scientific Events Using Existing Instruments



Normal Response Time

Sounding Rocket Programs
Supporting Scientific Accomplishments Summary

Past 5-year Period—FY 86 through FY 90

Element	Rockets
• Research Institutions	31
• Principal Investigator Teams	53
• Unique Research Missions Flown	150
• Estimated Science Instruments	≥ 600
• Vehicle Success	97%
• Science Success	87%

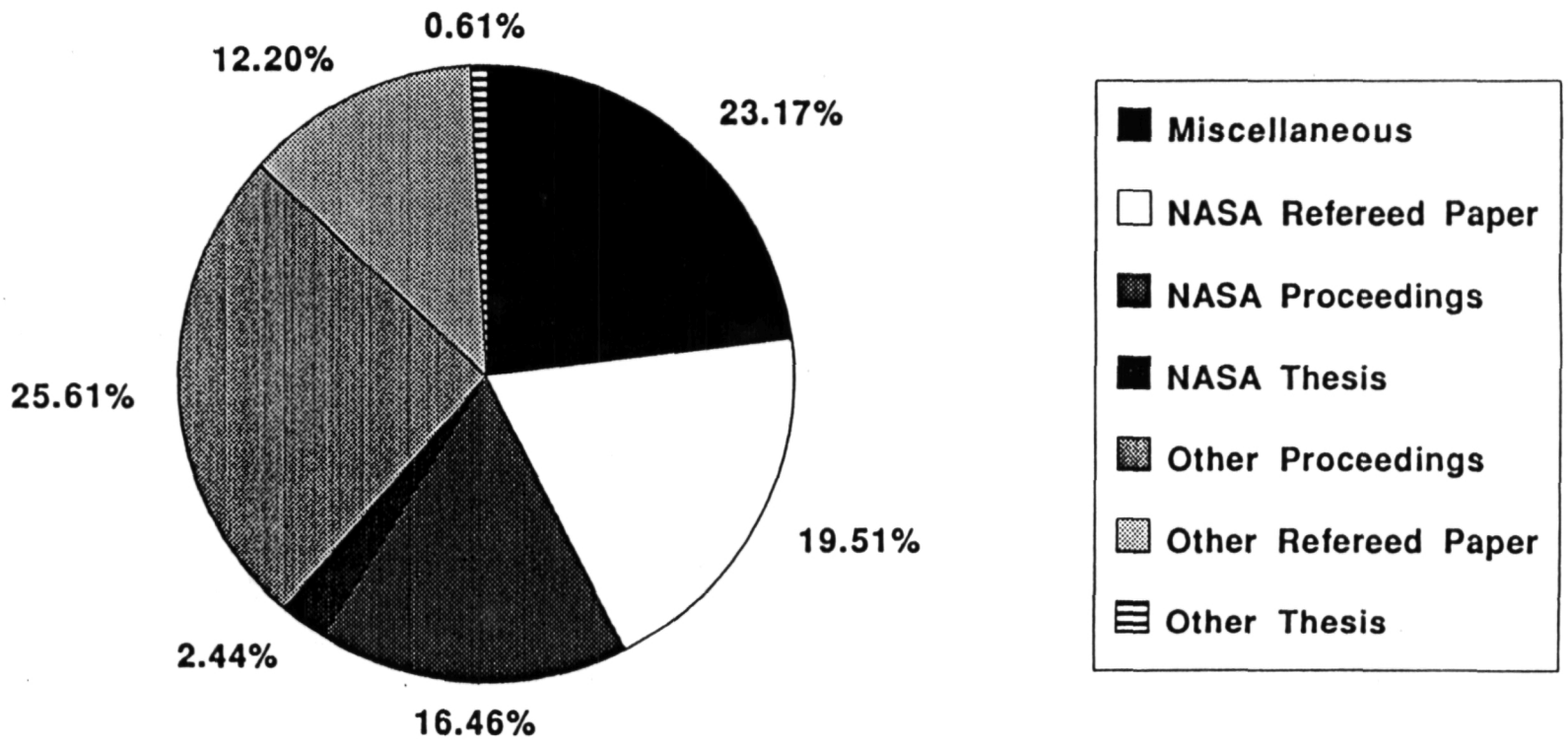
Research Launches by Institution
Five-year Period FY 86–90

Institution/FY	86	87	88	89	90	Total
1 U. Alabama, Huntsville	1			1		2
2 U. of Alaska	2	2		1		5
3 AS&E		1				2
4 Boston U.	1	1	2	1	4	9
5 U. California, Berkeley	1	2	1		2	6
6 Clemson U.		2				2
7 U. Colorado	1	1	4	4	4	14
8 Columbia U.			1		1	2
9 Cornell U.		4	2	1	1	8
10 GSFC	4	4	5	8	4	25
11 U. Houston					1	1
12 U. Illinois		1	3			4
13 Johns Hopkins U.	2			1	1	4
14 LMSC	1					1
15 U. Maryland	1					1
16 U. Michigan		1		1		2
17 U. Minnesota		1	1		1	3
18 MSFC	1					1
19 New Hampshire U.					1	1
20 NRL	2		1	1	3	7
21 Penn State U.	4	2	5		2	13
22 U. Pittsburgh	3	1	2	2	1	9
23 Princeton U.			1			1
24 SAO		1	1	1		3
25 Stanford U.			1			1
26 SwRI	2					2
27 TRW					1	1
28 U. Southern California				2	1	3
29 Utah State U.	6	5	1			12
30 WFF			1		2	3
31 U. Wisconsin	1			1		2
Total	33	29	33	25	30	150

Office of Space Science and Applications
Suborbital Program (Sounding Rockets)

Office of Space Science and Applications
Suborbital Program (Sounding Rockets)

SOUNDING ROCKET SCIENTIFIC PUBLICATIONS
Scientific & Technical Information Facility
Over 200 Entries in CY-90



Sounding Rocket Program Characteristics

- Each launch requires unique vehicle and science instrument configuration
- Development of new science instrument and sensor technology
- Low cost
- Quick response/short duration projects
- Higher risks/less formal R&QA—goal of 85% science mission success
- Mobile—worldwide launches from remote mobile sites determined by scientific opportunities
- Recovery—recalibration—reflight
- Operations—uniquely science driven
- Rapid response to scientific events
- Rapid publication of research results

WORKSHOP ON THE OSSA SUBORBITAL SCIENCE SOUNDING ROCKET PROGRAM

NOVEMBER 12-13, 1991

SCIENCE COMMUNITY INTERFACE

WERNER M, NEUPERT
PROJECT SCIENTIST FOR NASA SOUNDING ROCKETS

SCIENCE-COMMUNITY INTERFACES

UNIQUE ASPECTS OF SOUNDING ROCKET SCIENCE: WHY AND HOW DOES THE SCIENCE COMMUNITY USE THIS PROGRAM?

SELECTION PROCESS FOR SUBORBITAL SCIENTIFIC INVESTIGATIONS

OPERATIONAL CHARACTERISTICS OF SUBORBITAL SCIENCE INVESTIGATIONS

INTERFACES BETWEEN EXPERIMENTERS, NASA HEADQUARTERS AND THE RESPONSIBLE FIELD CENTER (GODDARD SPACE FLIGHT CENTER-WALLOPS FLIGHT FACILITY)

UNIQUE ASPECTS OF SOUNDING ROCKET SCIENCE

RELATIVELY SHORT TIME SPAN FROM EXPERIMENT APPROVAL TO FLIGHT

DIRECT, HANDS-ON EXPERIENCE IN INSTRUMENT DESIGN, FLIGHT HARDWARE, AND DATA ANALYSIS FOR GRADUATE STUDENTS AND YOUNG INVESTIGATORS

TEST BED FOR NEW TECHNOLOGY BEFORE COMMITTING TO LONG-TERM ORBITING SPACE FLIGHT

OPPORTUNITY FOR PRE-AND POST-FLIGHT CALIBRATION OF INSTRUMENTATION

OPPORTUNITY FOR "CAMPAIGNS" - GROUPS OF INVESTIGATIONS, FREQUENTLY COORDINATED SCIENTIFICALLY, THAT USE A COMMON LAUNCH LOCATION AND SUPPORT INFRASTRUCTURE

SELECTION PROCESS FOR SUBORBITAL SCIENTIFIC INVESTIGATIONS

PROPOSALS ARE SUBMITTED TO NASA IN RESPONSE TO A NASA RESEARCH ANNOUNCEMENT (NRA)

PROPOSAL EVALUATION MANAGED BY THE APPROPRIATE OSSA SCIENCE BRANCH

- SCIENTIFIC REVIEW BY DISCIPLINE SPECIALISTS IN THE AREA OF THE PROPOSAL

EVALUATION BASED ON:

- INTRINSIC SCIENTIFIC AND TECHNICAL MERIT
- RELEVANCE TO NASA'S PROGRAM OBJECTIVES AND BALANCE
- COST

SELECTION MADE BY A DESIGNATED NASA OFFICIAL

OPERATIONAL CHARACTERISTICS OF SUBORBITAL SCIENCE INVESTIGATIONS

EXAMPLES OF OPERATIONAL REQUESTS TO ACCOMPLISH SPECIFIC SCIENTIFIC OBSERVATIONS: TARGETED SCIENCE

TIMING OF LAUNCHES

- UNANTICIPATED ASTRONOMICAL TARGETS (COMETS, SUPERNOVAE)
- SPECIFIC SOLAR CONDITIONS (SOLAR ACTIVITY, TOTAL SOLAR ECLIPSE)
- TRANSIENT MESOSPHERIC PHENOMENA (HIGH LATITUDE NOCTILUCENT CLOUDS)
- TRANSIENT SOLAR-TERRESTRIAL PHENOMENA (AURORAE)
- CALIBRATION UP-DATES OF ORBITING INSTRUMENTATION

LAUNCH SITE SELECTION

- SITE SELECTION MAY BE BASED ON ACCESS TO PHENOMENA
  - (SOUTHERN HEMISPHERE - SUPERNOVA 1987A)
  - (HIGH LATITUDE NORTHERN HEMISPHERE - NOCTILUCENT CLOUDS)
- COORDINATION WITH GROUND-BASED FACILITIES

EXAMPLES OF OPERATIONAL REQUESTS (CONT.)

TRAJECTORY SELECTION

EXTREME ULTRAVIOLET SOLAR OBSERVATIONS REQUIRING HIGH ALTITUDE (H > 200 KM) TO MINIMIZE ATMOSPHERIC ABSORPTION

STRATIFIED PHENOMENA AT ALTITUDES NOT FEASIBLE FOR BALLOONS AND ORBITING SPACECRAFT (HIGH-LATITUDE NOCTILUCENT CLOUDS AT 83 KM)

MAGNETIC FIELD-ALIGNED PHENOMENA REQUIRING LARGE ALTITUDE RANGE (100 - 1200 KM)

ADDITIONAL UNIQUE OPERATIONAL ASPECTS OF SUBORBITAL SCIENCE

HIGH TELEMETRY BIT RATES PROVIDING RAPID SAMPLING OF PHENOMENA ALONG TRAJECTORY

COORDINATED PAYLOAD LAUNCHES TO GET COMPREHENSIVE COVERAGE OF MANY ASPECTS OF A PHENOMENON WITH MORE THAN ONE PAYLOAD

REAL-TIME SOLAR AND ASTRONOMICAL TARGET SELECTION AND VERIFICATION DURING THE FLIGHT

RETRIEVAL OF SPECIALIZED PHOTOGRAPHIC FILM PROVIDING HIGHER SPATIAL RESOLUTION THAN ELECTRONIC IMAGERS.

INTERFACES BETWEEN USER COMMUNITY AND NASA

NASA SOUNDING ROCKET WORKING GROUP REPRESENTING ALL SCIENCE DISCIPLINES

- CONTACT BETWEEN NASA HEADQUARTERS AND COMMUNITY DURING POLICY FORMULATION
- DIRECT INPUTS ON TECHNICAL NEEDS OF THE USER COMMUNITY
- REVIEW OF TECHNICAL DEVELOPMENTS OF THE PROGRAM

SOUNDING ROCKET AND BALLOON NEWSLETTER PUBLISHED BY OSSA

INVESTIGATOR/FIELD CENTER (WALLOPS FLIGHT FACILITY) INTERACTIONS

- PROJECT INITIATION CONFERENCE
- PRE-INTEGRATION REVIEW
- MISSION READINESS REVIEW
- FAILURE REVIEW, IF NEEDED

NASA Workshop

on

THE SUBORBITAL SCIENCE

SOUNDING ROCKET PROGRAM

12-13 November , 1991

Presentation Summary: Investigator Perspectives

Michael Mendillo
Professor of Astronomy

OUTLINE

1. SCIENCE PAYLOAD REQUIREMENTS

2. SUPPORTING SERVICES

3. "SPECIAL" REQUIREMENTS

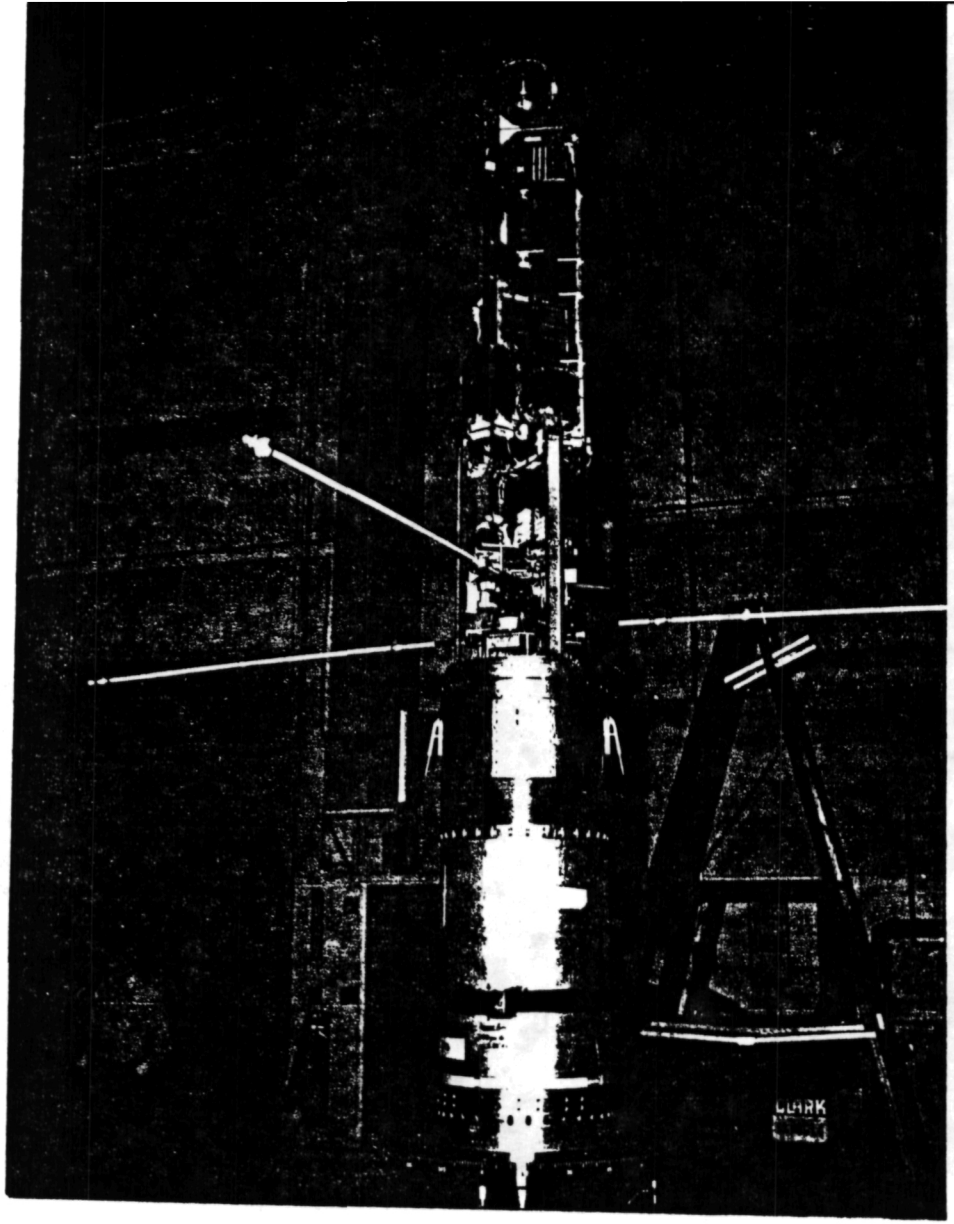
1. SCIENCE PAYLOAD REQUIREMENTS

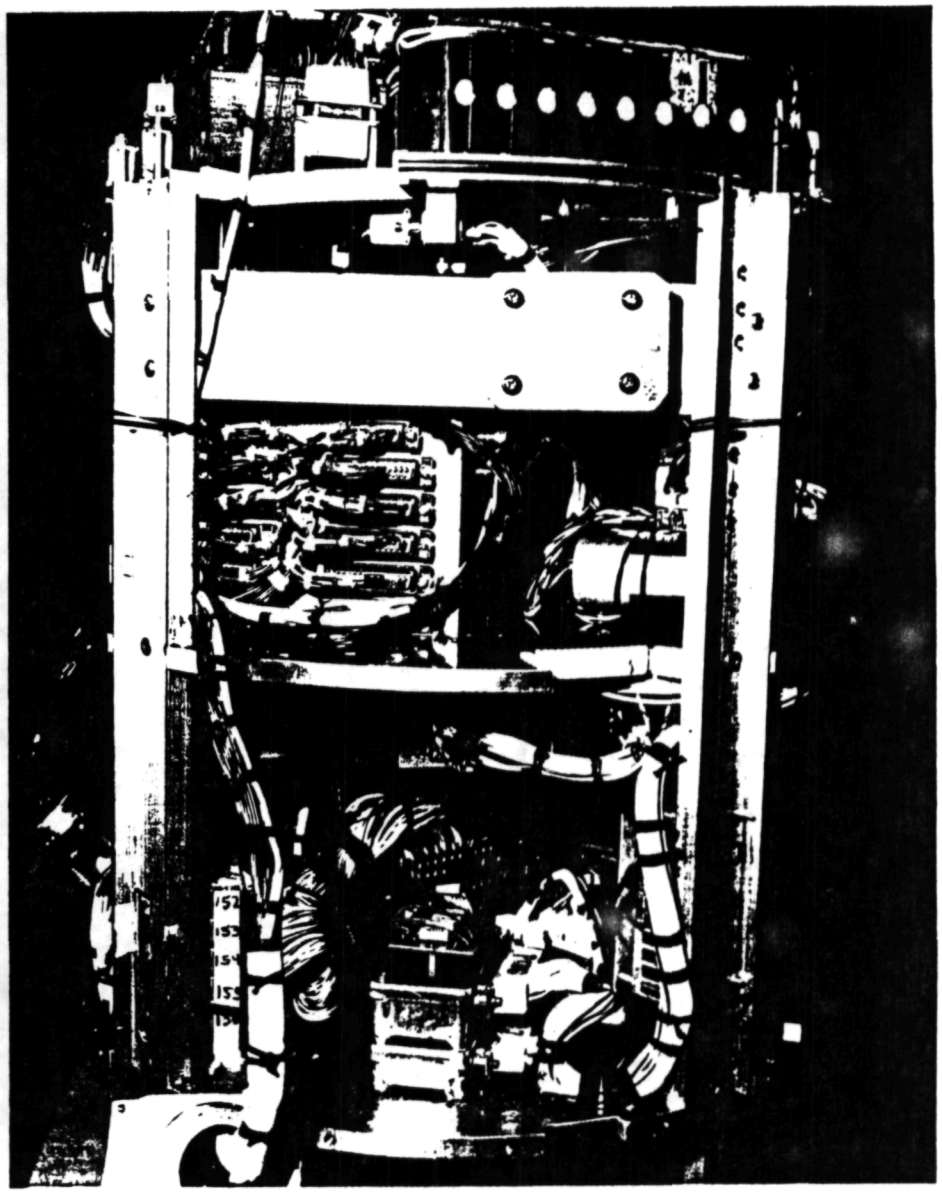
- Pointing --- "simple" (instrument $\perp \mathbf{B}_0$, $\parallel \mathbf{V}$, etc)
- Pointing --- "complex" (stellar, planetary, solar targets)
- Deployments -- Booms, shields, etc.
- Separations --- "Mother-Daughter" payloads, ejectables, etc.
- Chemical Releases --- Multiple species
- Payload Recovery Systems --- re-use, retrieve data
- Down Link Telemetry --- Date rates, decision points
- Up-link Commands

----- Above items currently a mix of PI/NASA provided.

EXAMPLES OF PAYLOADS

- Simple --- Chemical Releases to modify atmosphere
- Moderate --- In-situ probes of space environment
- Complex --- Short term platform for astronomical observations





CORNELL UNIVERSITY PAYLOADS

UNIVERSITY OF COLORADO
PLANETARY ROCKET PROGRAM

SCIENCE OBJECTIVES

- ULTRAVIOLET IMAGING AND SPECTROSCOPIC OBSERVATIONS OF MERCURY, VENUS, AND COMETS

SCIENCE INSTRUMENT

- A 40 CM DIAMETER CASSEGRAIN TELESCOPE AND A SPECTROGRAPH EQUIPPED WITH AN IMAGE INTENSIFIED TV CAMERA AND A CODACON MICROCHANNEL PLATE DETECTOR

- THE TELESCOPE SECONDARY MIRROR IS MOUNTED IN A TWO AXIS GIMBAL WHICH CAN BE MOVED DURING FLIGHT BY GROUND COMMANDS IN ORDER TO REPOSITION THE TARGET IMAGE ON THE ENTRANCE SLIT OF THE SPECTROGRAPH. POINTING ACCURACY AND STABILITY OF 1 ARC SECOND IS ACHIEVED USING THIS SYSTEM.

SPECIAL REQUIREMENTS

- A LARGE SUNSHADE MUST BE DEPLOYED AND RETRACTED DURING FLIGHT.

- THE ROCKET ATTITUDE CONTROL SYSTEM MUST POINT TO THE TARGET WITH HIGH PRECISION (WITHIN 3 ARC MINUTES) AND STABILITY (RESIDUAL MOTION LESS THAN 20 ARC SECONDS).

- THE EXPERIMENT USES A SENSITIVE , LIGHT-WEIGHT TELEVISION CAMERA TO MONITOR THE TARGET IMAGE AT THE FOCAL PLANE OF THE TELESCOPE.

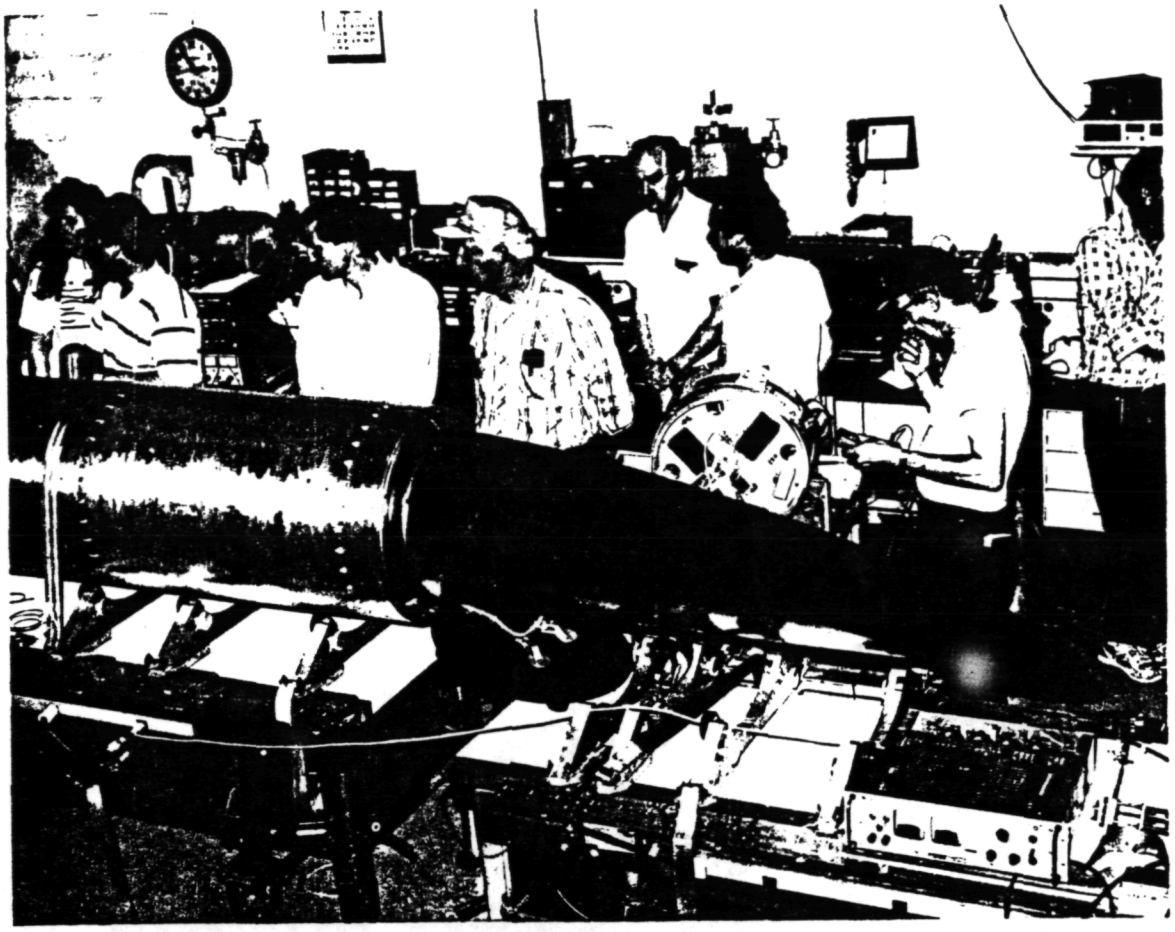
- INSTRUMENT FINE POINTING IS CONTROLLED BY GROUND COMMAND DURING FLIGHT.

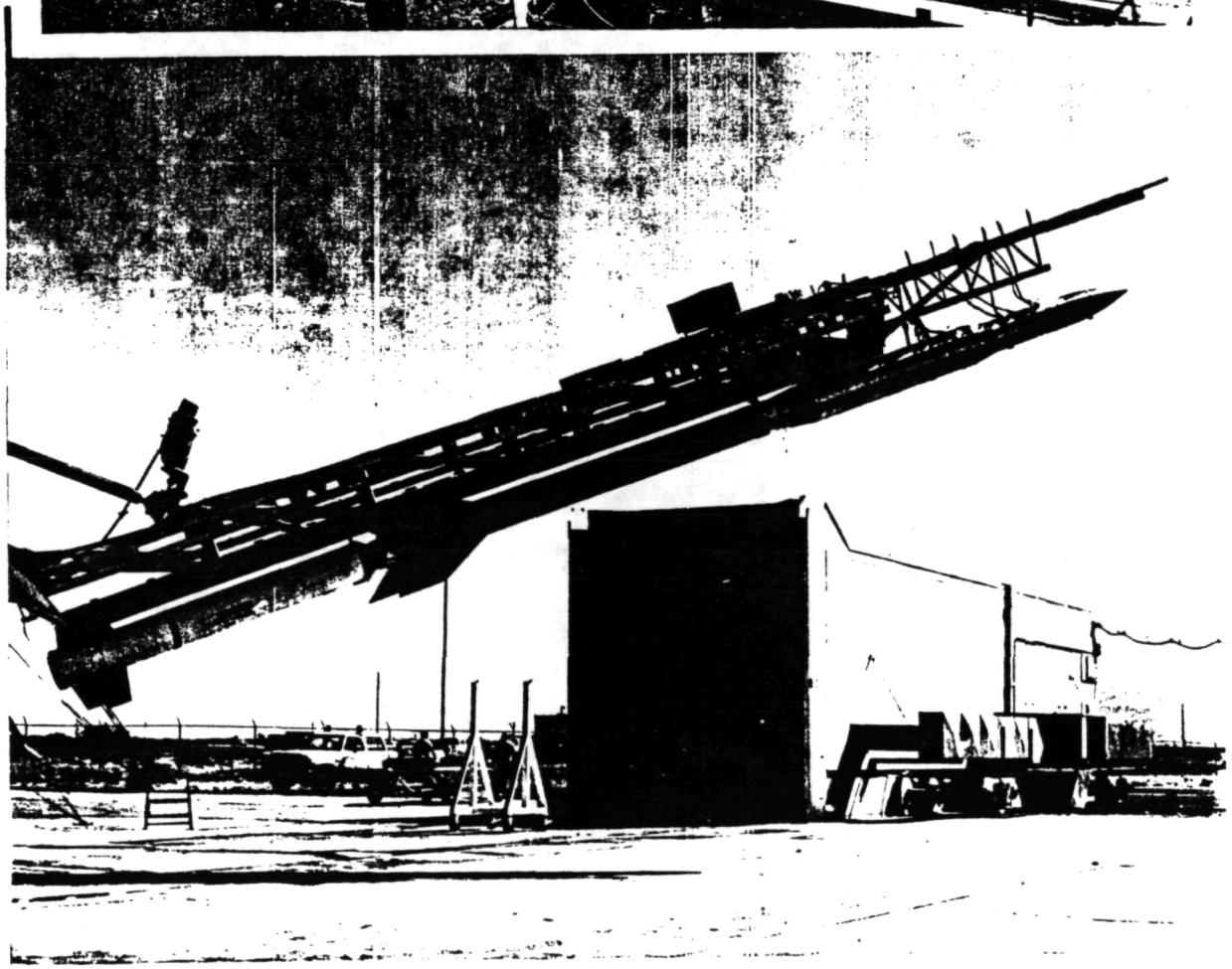
OBSERVATION SCENARIO

- LAUNCH WINDOW CONSTRAINTS ARE DETERMINED BY THE POSITION OF THE PLANETS AND MAY BE AS LIMITED AS ONE WEEK PER YEAR AND 15 MINUTES PER DAY.

- TWO GUIDE TARGETS MUST BE ACQUIRED BEFORE FINAL PAYLOAD MANEUVER TO TARGETS NEAR THE SUN.

- AFTER THE NEAR-SUN TARGET IS ACQUIRED TELESCOPE FINE-MODE CONTROL IS ACTIVATED ALLOWING THE TARGET IMAGE POSITION ON THE ENTRANCE SLIT OF THE SPECTROMETER.





UNIVERSITY OF COLORADO PAYLOAD

FIGURES DESCRIBING THE UNIVERSITY OF COLORADO PLANETARY ROCKET

FIGURE 1 Figure 1 shows a diagram of the science instrument which consists of a 40 cm diameter Cassegrain telescope and Ebert-Fastie spectrograph. A NASA provided star tracker is mounted in front of the secondary mirror and provides pointing information for the rocket attitude control system. During an observation a control system consisting of a gimbal mount for the secondary mirror and an optical sensor located near the telescope focal plane holds the image of a target stationary on the entrance slit of the spectrograph. The location of the image can be changed during flight by ground commands. The combination of ACS system, telescope image motion compensation, and ground commands allow the image of a target to be positioned to 1 arc second with less than 1 arc second of image jitter A sensitive TV camera which is used to monitor the position of the target image in the focal plane is not shown in this figure.

FIGURE 2. Figure 2 shows the science instrument combined with a sunshade which allows for pointing the telescope at targets within 17 degrees of the sun.

FIGURE 3. Figure 3 shows a typical viewing geometry for the instrument with the sunshade deployed.

FIGURE 4 Figure 4 shows the observing sequence for the planet Venus used during flight 27.110 UL which occurred in September 1988. The horizontal bars show the location and size of the spectrograph entrance slit as it appears on the telescope TV camera. During the flight the slit was moved by ground command 24 times to sweep form the equator to the south pole, off the limb, and then to approximately 50 degrees north latitude.

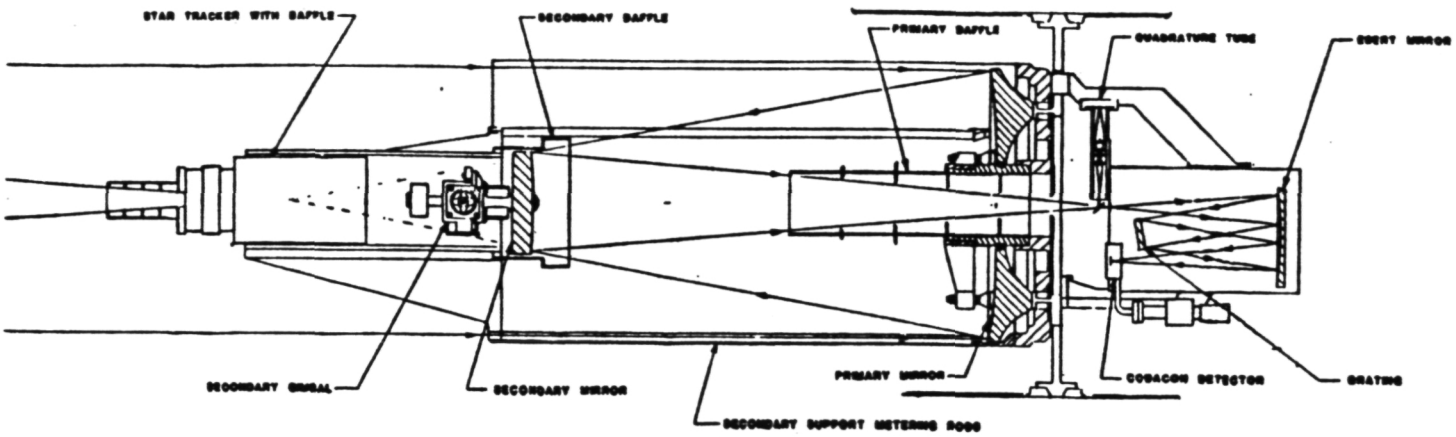


FIGURE 1. PLANETARY ULTRAVIOLET TELESCOPE-SPECTROGRAPH

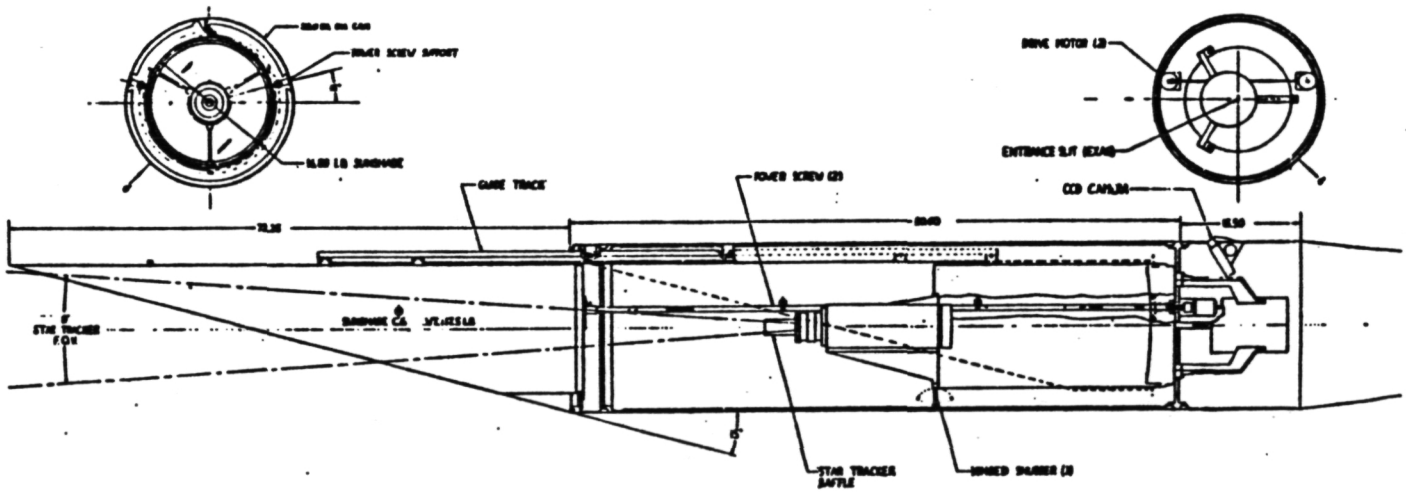


FIGURE 2. COLORADO PLANETARY ULTRAVIOLET TELESCOPE-SPECTROGRAPH EQUIPPED WITH A 17° SUNSHADE

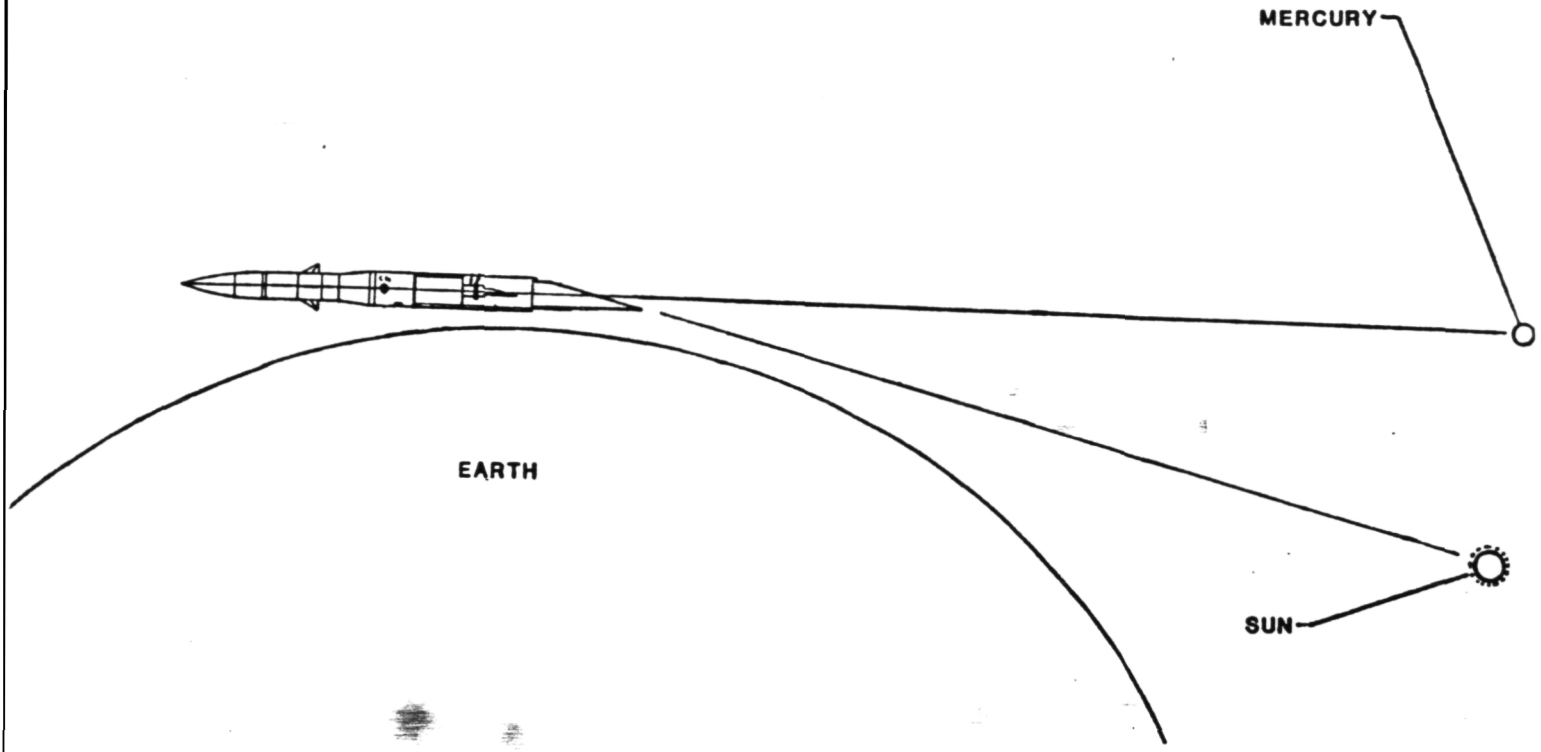


FIGURE 3.

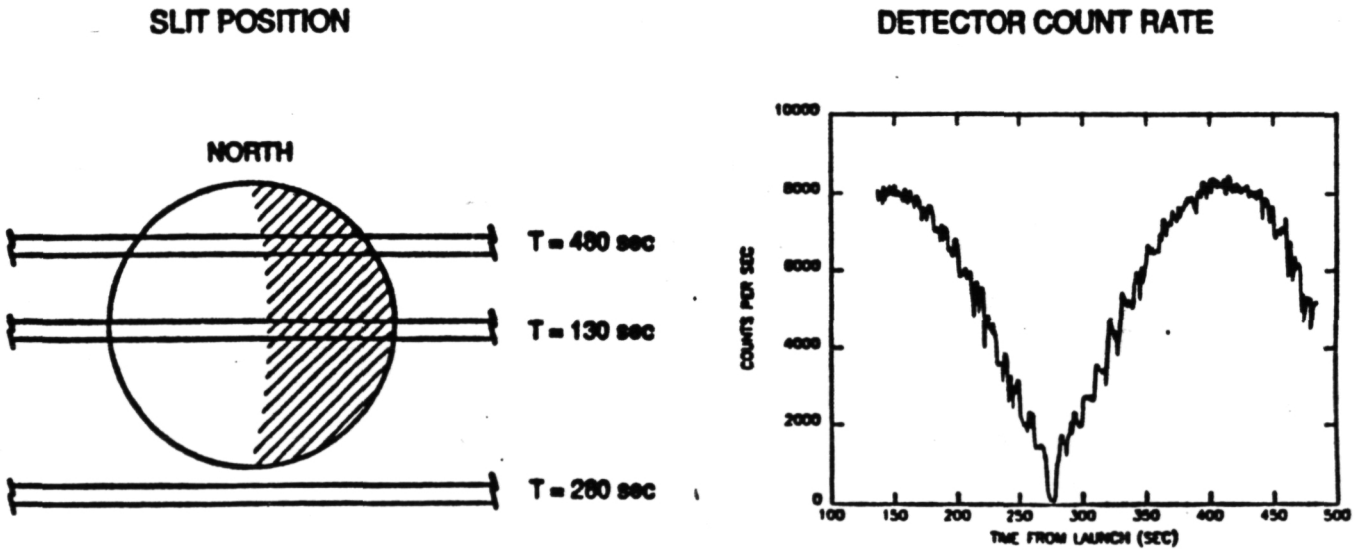


FIGURE 4. VIEWING GEOMETRY FOR ROCKET 27.110

2. SUPPORTING SERVICES

- Parts/component advice, certifications, reliability, supply
- Modelling --- temperatures, **g**-forces, vibrations, etc.
- Testing --- Q/A, flight readiness
- Trajectories --- simulations, targeting

- LOGISTICS

---- "Traditional" sites

---- Specialized campaigns

---- Equipment shipping to remote sites

---- Groundbased diagnostic sites --- telecommunications for real-time decisions on launch

--- Science team travel to specialized sites
-- e.g., use of MAC

EXAMPLES OF LOGISTICAL CONCERNS

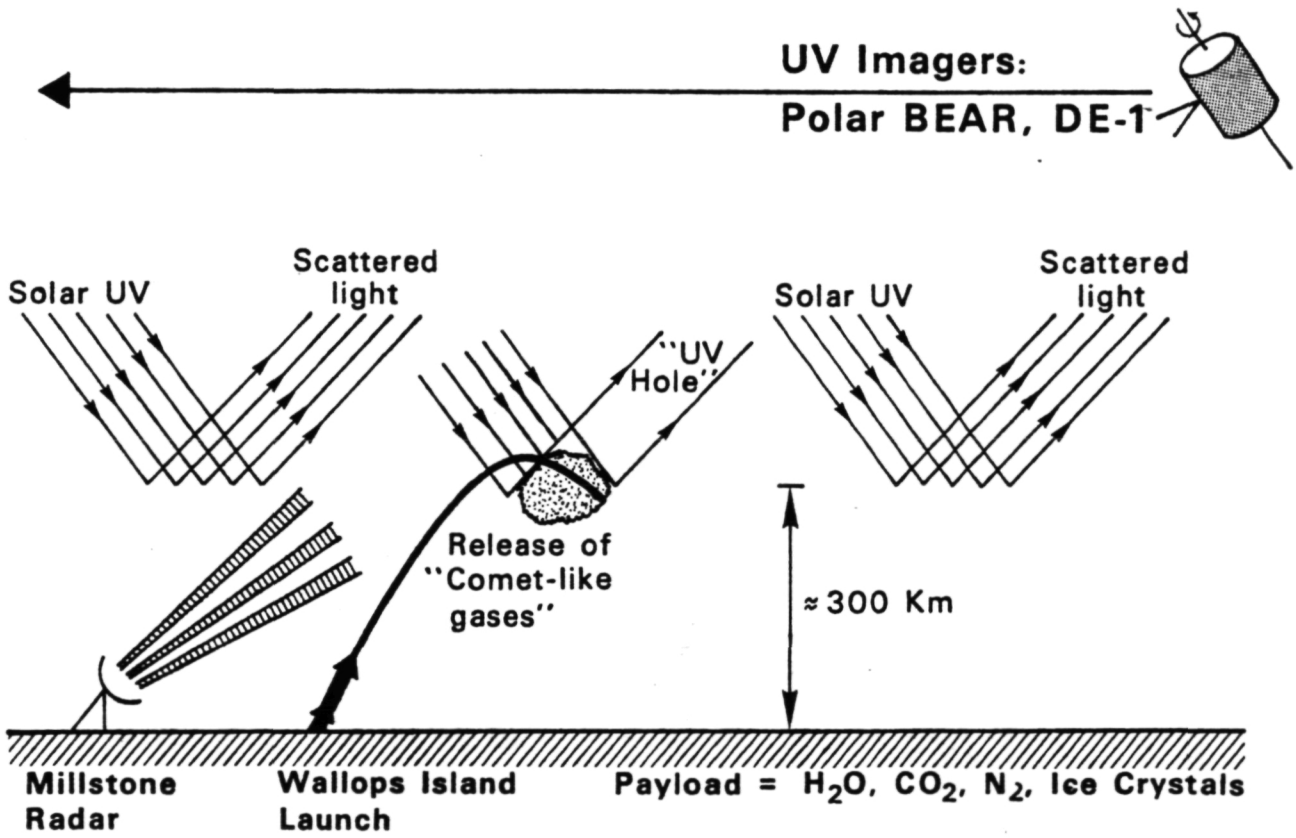
- Traditional Site --- ERIC Experiments at Wallops Island

- Specialized Campaigns --- COPE/Greenland, 1987

  --- CRRES/Kwajalein, 1990

Environmental Reactions Induced by Comets

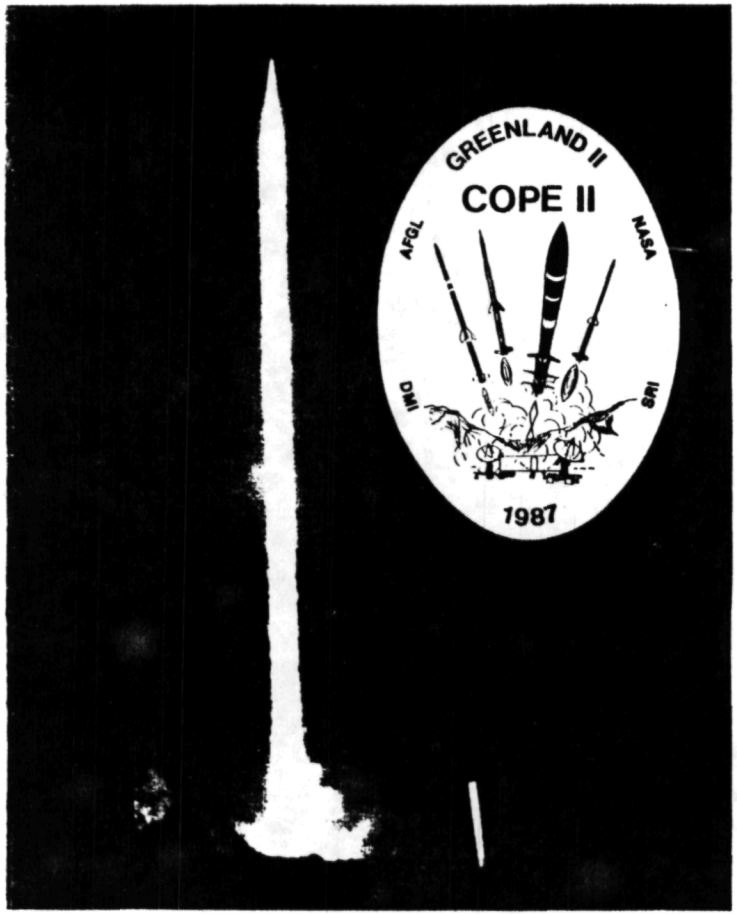
Project ERIC - - Experiment Design



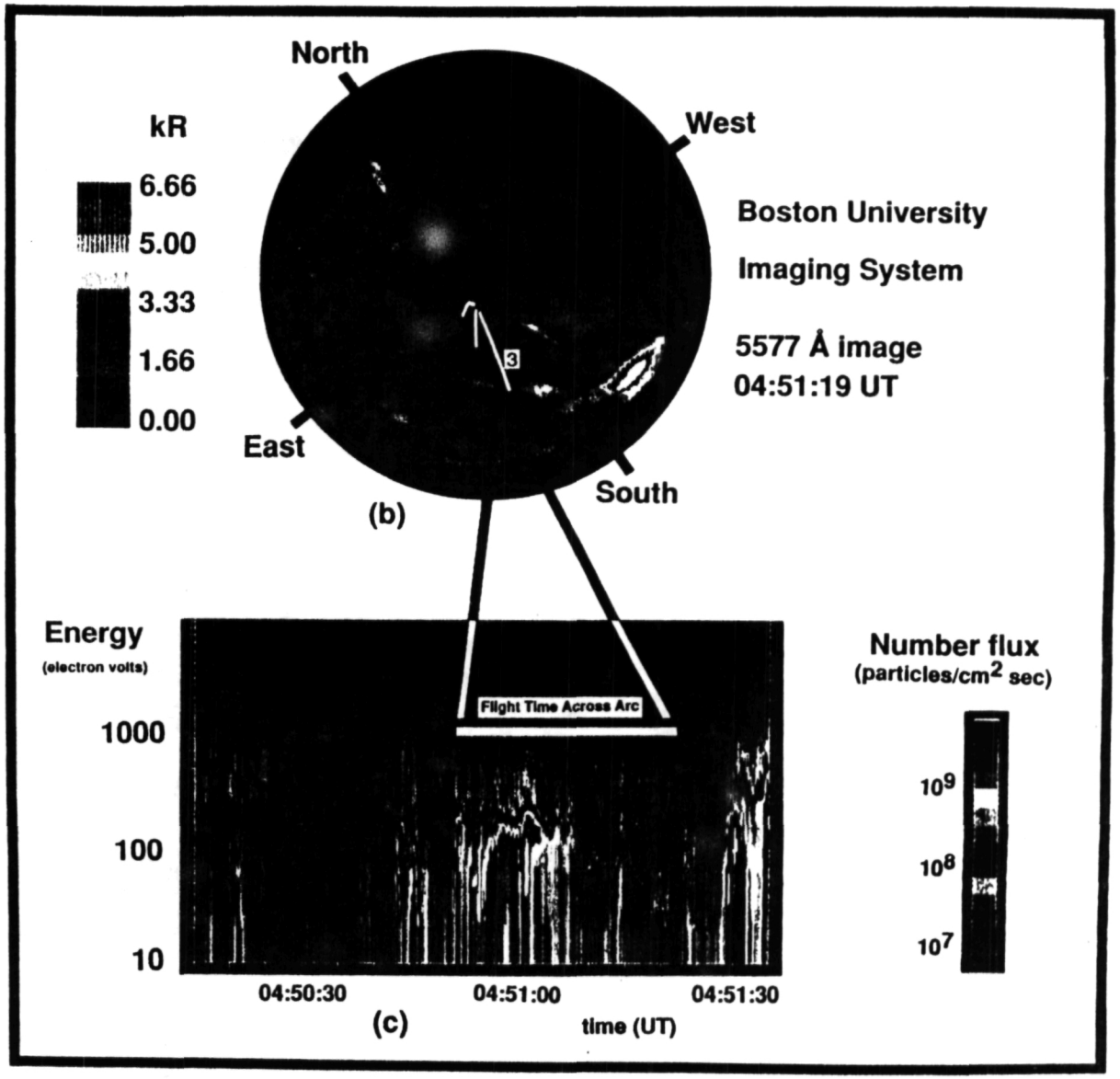
Sondre Stromfjord
March 31 1987

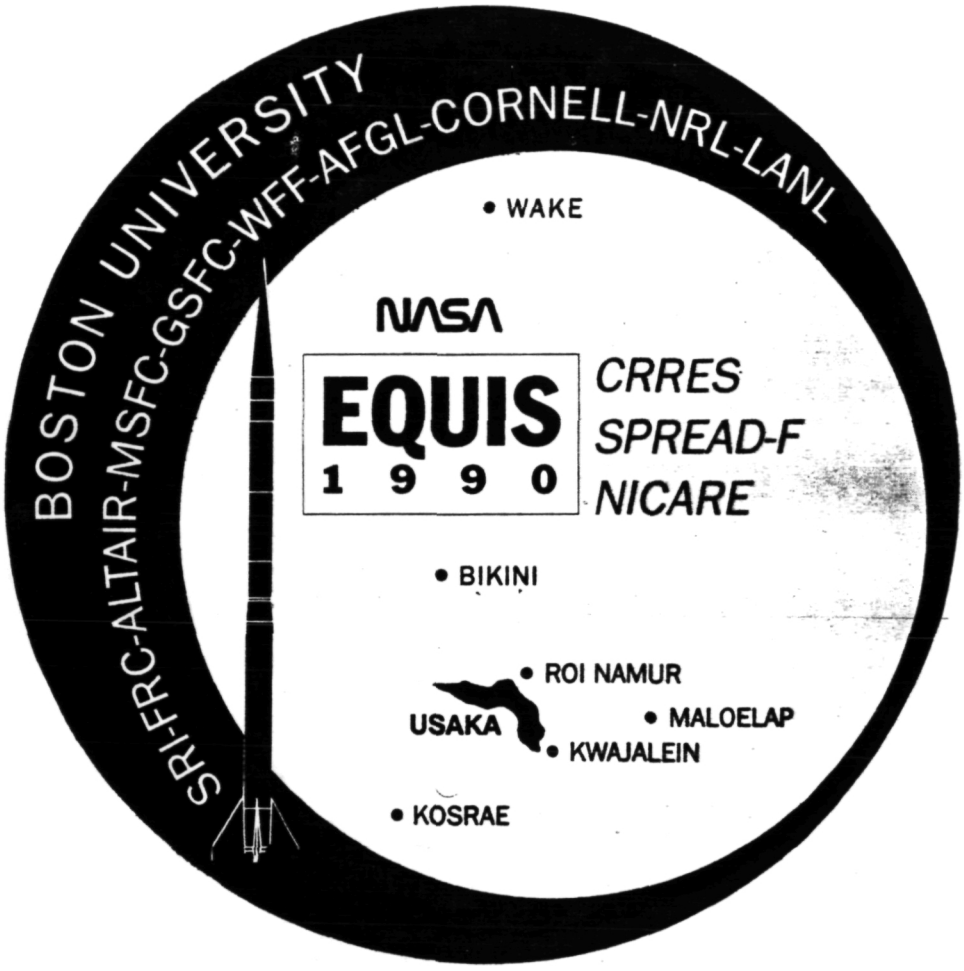
Cooperative Observations of Polar Electrodynamics

CORNELL UNIVERSITY PAYLOADS



(a)




BOSTON UNIVERSITY
SRI-FRC-ALTAIR-MSFC-GSFC-WFF-AFGL-CORNELL-NRL-LANL
• WAKE
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• ROI NAMUR
USAKA
• MALOELAP
• KWAJALEIN
• KOSRAE

3. SPECIAL REQUIREMENTS

- FLEXIBILITY
- MORE FLEXIBILITY
- Training of students (science & engineering)
- Access to space for new investigators
- Instrument development
- Launch windows that are target and site dependent
  (e.g., eclipse)
  or seasonally dependent
  (e.g., equatorial ionospheric instabilities)
- Launch criteria that are event dependent
  (e.g. auroral displays)
- Coordination with satellite passes
- Quick response to unanticipated events
  (e.g., supernova)
  or targets-of-opportunity
  (Ulysses-Jupiter encounter)

NASA SPACE SCIENCE

SUBORBITAL ROCKET PROGRAM WORKSHOP

(PROGRAM IMPLEMENTATION/OPERATIONS)

NOVEMBER 12-13, 1991

NASA SOUNDING ROCKETS

SPECIAL FEATURES

- HIGH RELIABILITY
- SHORT MISSION LEAD TIME
- LOW COST
- MOBILE
- PAYLOAD RECOVERY AND RE-USE
- APPLICABILITY TO GRADUATE SCHOOL RESEARCH PROGRAMS

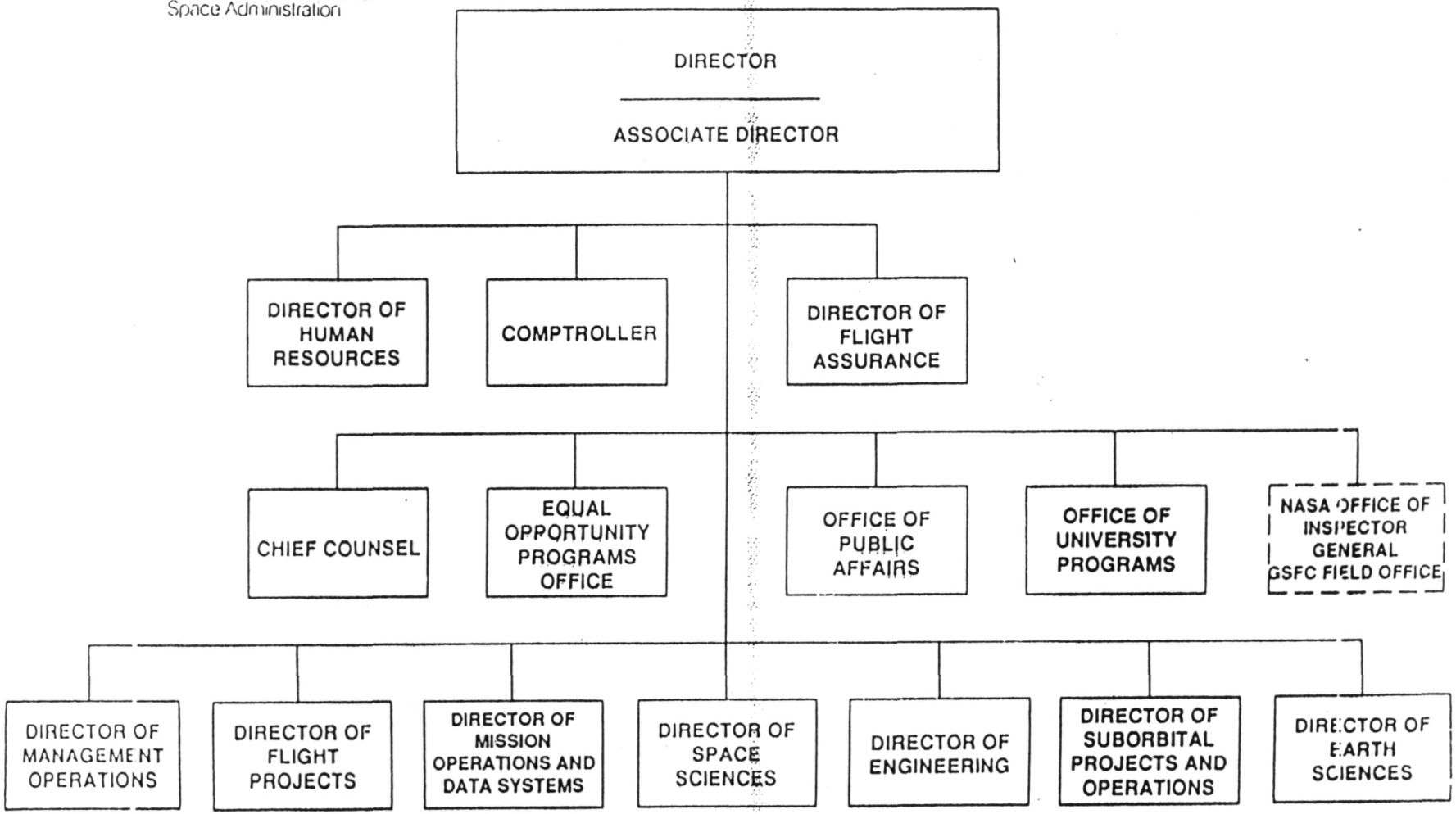
NASA SOUNDING ROCKET PROGRAM

OVERVIEW

- **~30 SOUNDING ROCKETS PER YEAR**
  - PAYLOADS RANGE - 5 TO 1150 KILOGRAMS
  - PEAK ALTITUDES RANGE - 70 TO 1500 KM
- **SERVES SCIENTIFIC COMMUNITY**
  - UNIVERSITIES
  - NASA
  - INTERNATIONAL
  - OTHER GROUPS
- **PROGRAM SUPPORT**
  - PLASMA PHYSICS
  - UPPER ATMOSPHERE
  - GALACTIC ASTRONOMY
  - SOLAR PHYSICS
  - HIGH ENERGY ASTROPHYSICS
  - PLANETARY ATMOSPHERES
- **OVER 2500 TOTAL MISSIONS SINCE 1959**
  - AT OVER 86% MISSION SUCCESS
- **398 MISSIONS IN PAST ELEVEN YEARS**
  - AT 88% MISSION SUCCESS
  - AT 98% VEHICLE SUCCESS

NASA
National Aeronautics and Space Administration

GODDARD SPACE FLIGHT CENTER



APPROVED James R. Thompson

DATE 8/29/90

NASA SOUNDING ROCKET PROGRAM

GSFC/CODE 800 PRIMARY SUPPORT

- MANAGEMENT
- DEVELOPMENT AND PROCUREMENT OF PAYLOADS/SPECIAL SYSTEMS
- DEVELOPMENT AND PROCUREMENT OF LAUNCH VEHICLES
- PAYLOAD TESTING AND EVALUATION
- ANALYTICAL STUDIES
- LAUNCH RANGE OPERATIONS/INTERFACES
- TRACKING AND DATA ACQUISITION AND DATA PROCESSING

NASA SOUNDING ROCKET PROGRAM

LAUNCHES BY DISCIPLINE

FISCAL YEAR	80	81	82	83	84	85	86	87	88	89	90	91
GALACTIC ASTRONOMY	4	5	3	5	4	4	4	1	3	2	6	2
HIGH ENERGY ASTROPHYSICS	5	2	4	3	1	1	2	0	4	1	1	2
SOLAR PHYSICS	9	2	3	5	1	1	1	4	5	4	0	6
PLASMA PHYSICS	17	25	26	29	24	21	14	18	16	10	17	10
UPPER ATMOSPHERE	11	7	4	6	6	9	9	5	3	4	1	2
PLANETARY ATMOSPHERES	3	4	5	3	3	1	3	1	1	4	3	2
OTHER	2	3	0	2	1	0	0	0	1	0	2	1
TOTAL	51	48	45	53	40	37	33	29	33	25	30	25

11-06-91 LAUDISTB

NASA Sounding Rocket Launch Locations

*Andoya, Norway - Fixed Range (Full Facilities)
Antigua, U.K. - Mobile Range Site
Ascension Island, U.K. - Mobile Range Site
Barking Sands, HI - Fixed Range (Full Facilities
Barter Island, AK - Mobile Range Site
Cape Parry, Canada - Mobile Range Site
Camp Tortuguera, Puerto Rico - Mobile Range Site
Chikuni, Canada - Mobile Range Site
Coronie, Suriname - Mobile Range Site
Eglin AFB, FL - Fixed Range (Full Facilities)
El Arenosillo, Spain - Fixed Range
Fort Churchill, Canada - Fixed Range (Decommissioned)
Fort Greely, AK - Mobile Range Site
Fort Sherman, Panama - Mobile Range Site
Fox Main, Canada - Mobile Range Site
Karachi, Pakistan - Fixed Range
Karikari, New Zealand - Mobile Range Site
Kerguelen Island, France - Mobile Range Site
Keweenaw, MI - Mobile Range Site
*Kiruna (Esrange), Sweden - Fixed Range (Full Facilities)
Kourou, French Guiana - Fixed Range (Full Facilities)
*Kwajalein, Marshall Is. - Fixed Range (Full Facilities)
Natal, Brazil - Fixed Range (Full Facilities)
Point Barrow, AK - Fixed Range (Decommissioned)
Point Mugu, CA - Fixed Range (Full Facilities)
*Poker Flat Research Range, AK - Fixed Range (Full Fac.)
Primrose Lake, Canada - Mobile Range Site
Punta Lobos, Peru - Mobile Range Site
Red Lake, Canada - Mobile Range Site
Resolute Bay, Canada - Mobile Range Site
San Marco, Kenya - Fixed Range
Sardinia, Italy - Mobile Range Site
Siple Station, Antarctica - Mobile Range Site
*Sondre Stromfjord, Greenland - Mobile Range Site
Thumba, India - Fixed Range
U.S.N.S. Croatan - Shipboard Range (Decommissioned)
U.S.N.S. Range Recoverer - Shipboard (Decommissioned)
*Wallops Island, VA - Fixed Range (Full Facilities)
Western Test Range, CA - Fixed Range (Full Facilities)
*White Sands Missile Range, NM - Fixed Range (Full Fac.)
*Woomera, Australia - Fixed Range (Partial Facilities)

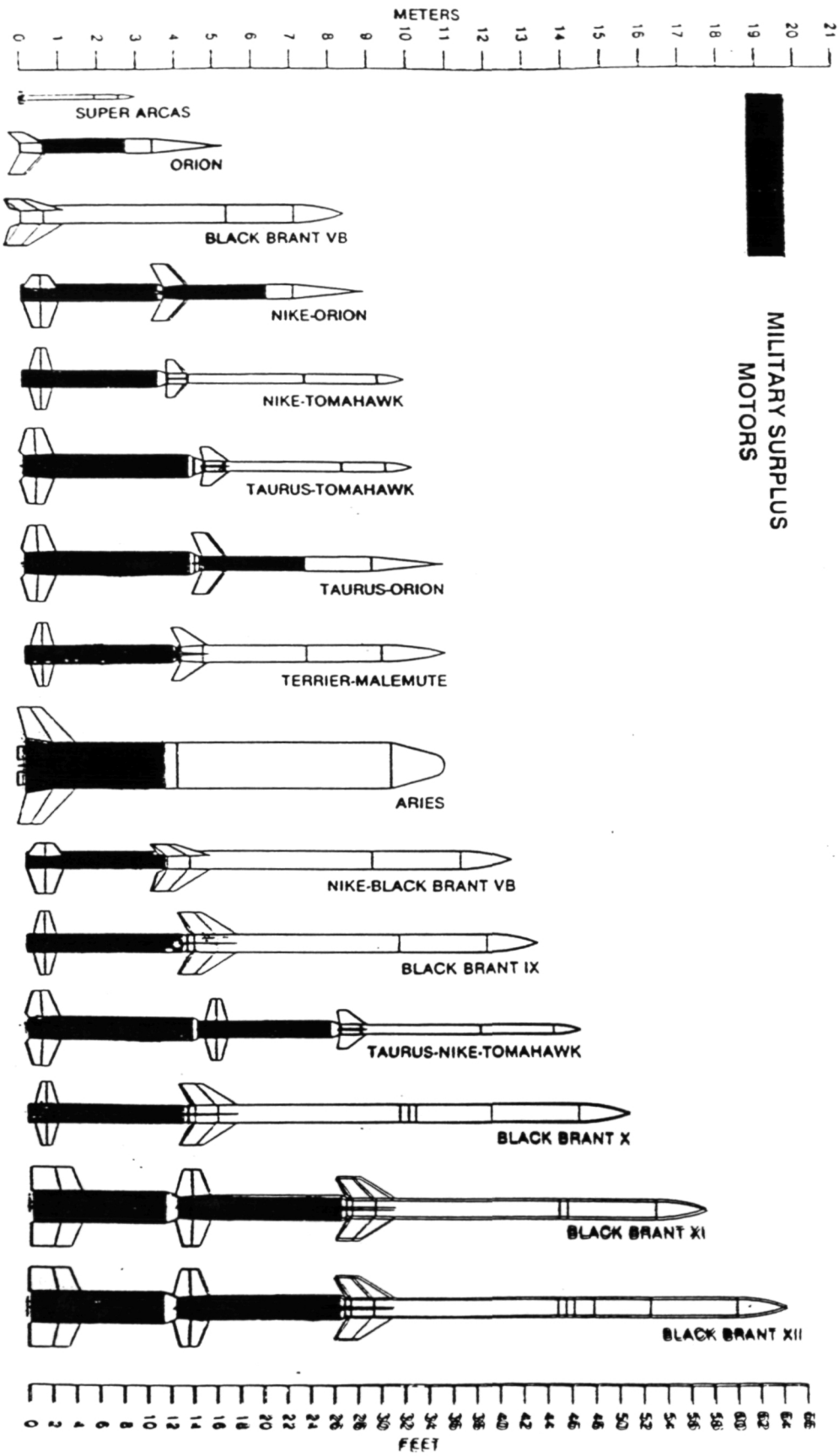
*Currently used sites

NASA SOUNDING ROCKET PROGRAM
LAUNCHES BY LOCATION

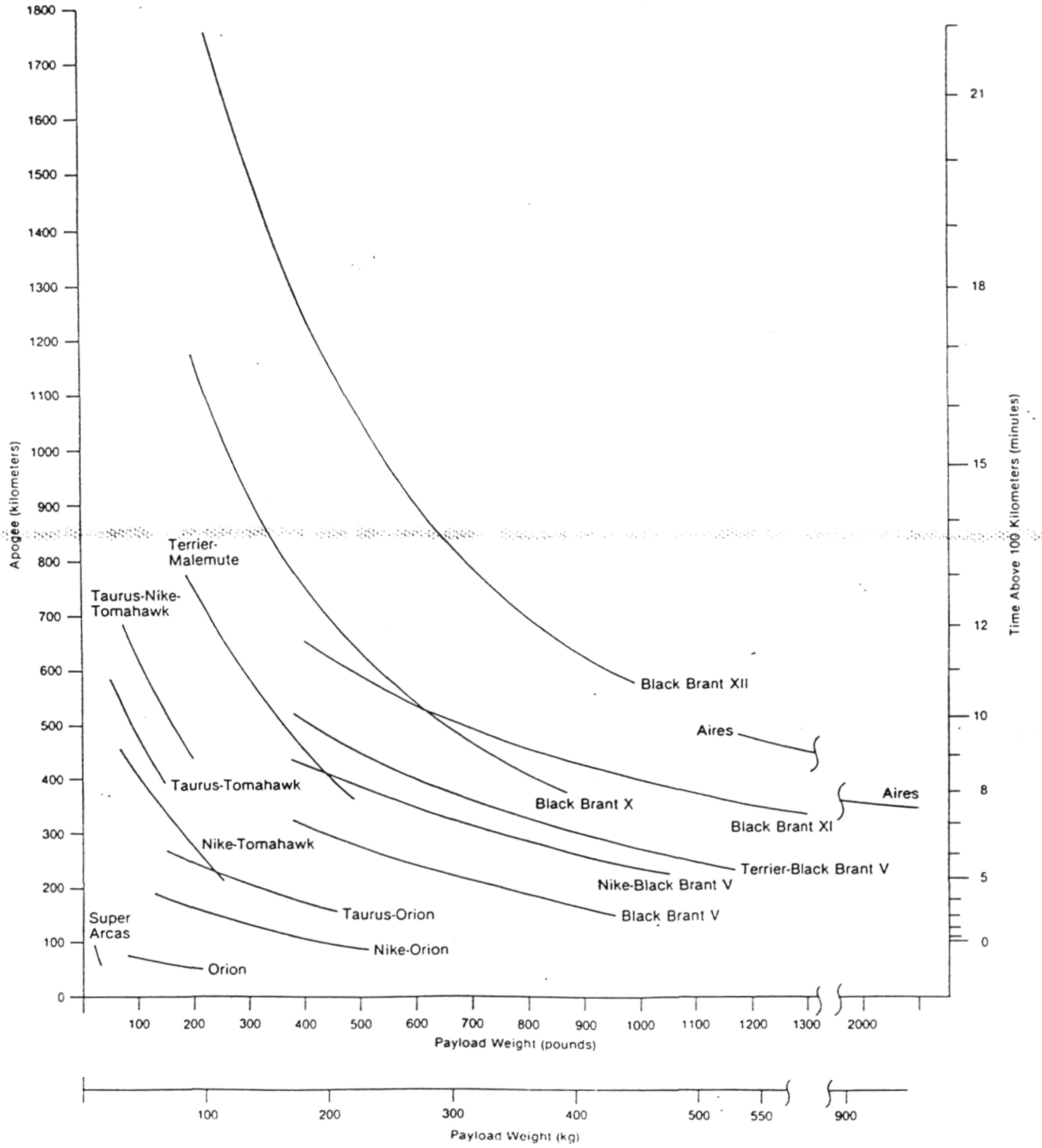
	80	81	82	83	84	85	86	87	88	89	90	91
ANTARCTICA - SIPLE STATION		7										
ALASKA - FORT YUKON					1							
POKER FLAT	5	2	14	5	7	8	8	2	3	2	7	3
AUSTRALIA - WOOMERA									6			
CANADA - CAPE PARRY			4									
CHURCHILL RSCH. RNG.	1	3	4	2	3	3				4		
GREENLAND - SONDRE STROMFJ.						7		8				
KWAJALEIN											7	
KENYA - SAN MARCO	7											
NORWAY - ANDOYA		6	1		1		2	4	8	3		1
PERU - PUNTA LOBOS				18								
SWEDEN - KIRUNA		4					3		1	2		7
WALLOPS ISLAND - VIRGINIA	14	12	4	7	17	6	6	7	5	2	4	1
WHITE SANDS - NEW MEXICO	24	14	18	21	11	13	14	8	10	12	12	13
TOTAL	51	48	45	53	40	37	33	29	33	25	30	25

11-05-91 LAULOC

NASA Sounding Rockets

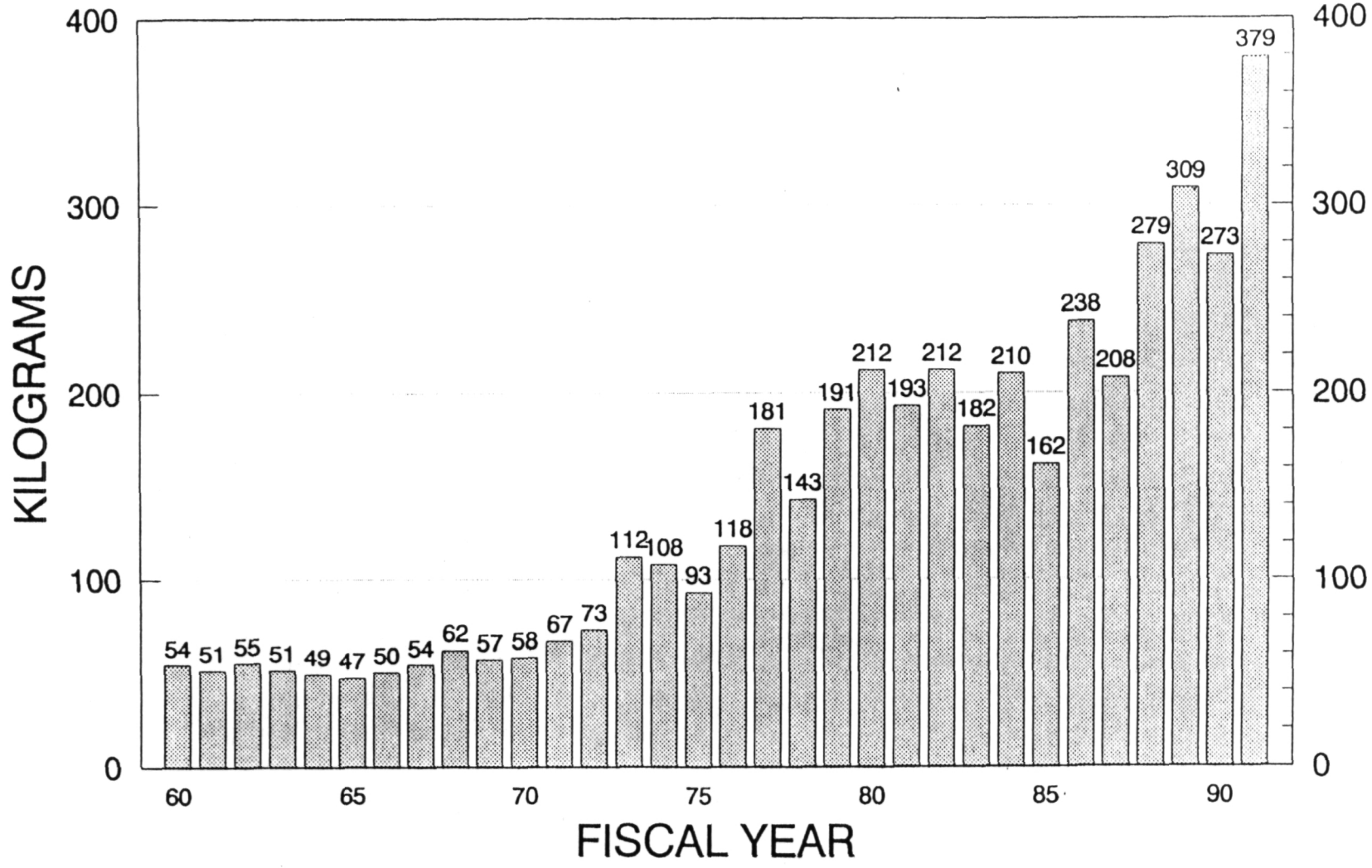


NASA Sounding Rocket Performance



NASA SOUNDING ROCKETS

GROWTH IN AVERAGE WEIGHT OF PAYLOADS



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NASA SOUNDING ROCKET PROGRAM
LAUNCHES BY VEHICLE

	79	80	81	82	83	84	85	86	87	88	89	90	91
24 ARIES	2	1	1	1		1		1					1
04 AEROBEE 150		2		1	2		1						
13 AEROBEE 170	2												
17 AEROBEE 350				1	1	1							
23 ASTROBEE D	6	4											
25 ASTROBEE F	12	9	3	1									
15 SUPER ARCAS	5	4	6	3	9	6	2	5	4				3
21 BLACK BRANT V	4	1	2	1	4	3	3	2		1	4		3
27 NIKE-BLACK BRANT	6	11	8	9	9	6	4	4	5	3	2	2	1
36 BLACK BRANT IX					2			5	6	15	9	12	11
35 BLACK BRANT X				4	1	3	2	5	1	2	5	2	
39 BLACK BRANT XI												1	
40 BLACK BRANT XII												1	1
30 ORION		3	8	1	2	2	6	1	2	3		1	
31 NIKE-ORION	2	7	3	10	8	9	9	5	1	7	2	1	4
33 TAURUS-ORION	2	4	11	4	10	4	5	1	3		2	2	
38 TAURUS-NIKE-TMHWK						2		3	3	1		4	
34 TAURUS-TOMAHAWK	3	3	2	2	2		2		1				
18 NIKE-TOMAHAWK	9		3	4			1		1				
29 TERRIER-MALEMUTE	3	1		3	2	2	2	1	2		1	2	
12 SPECIAL		1	1		1	1				1		2	1
TOTAL	56	51	48	45	53	40	37	33	29	33	25	30	25

11-05-91 LAUVEH

LAUNCH VEHICLE SUPPORT FOR NASA SOUNDING ROCKET PROGRAM

- PURCHASE COMMERCIAL SOLID PROPELLANT ROCKET MOTORS/HARDWARE
  - BLACK BRANT V (BRISTOL)
  - NIHKA (BRISTOL)
  - TOMAHAWK (THIOKOL)
  - MALEMUTE (THIOKOL)
  - SUPER ARCAS (ATLANTIC RESEARCH)
- EXTENSIVE USE OF SURPLUS TACTICAL ROCKET MOTORS/HARDWARE
  - HAWK, IMPROVED HAWK
  - NIKE
  - IMPROVED HONEST JOHN
  - TALOS
- CONTRACT PURCHASE OF OTHER VEHICLE HARDWARE
- UTILIZE S-19 BOOST-GUIDANCE SYSTEM AT WHITE SANDS MISSILE RANGE
- USE SUPPORT CONTRACTORS (*ON AND OFF-SITE*)
  - MISSION ANALYSES
  - SYSTEMS ENGINEERING
  - PROTOTYPE FABRICATION
  - VEHICLE ASSEMBLY/LAUNCH OPERATIONS
- AVERAGE ANNUAL EXPENDITURE APPROXIMATELY $8M

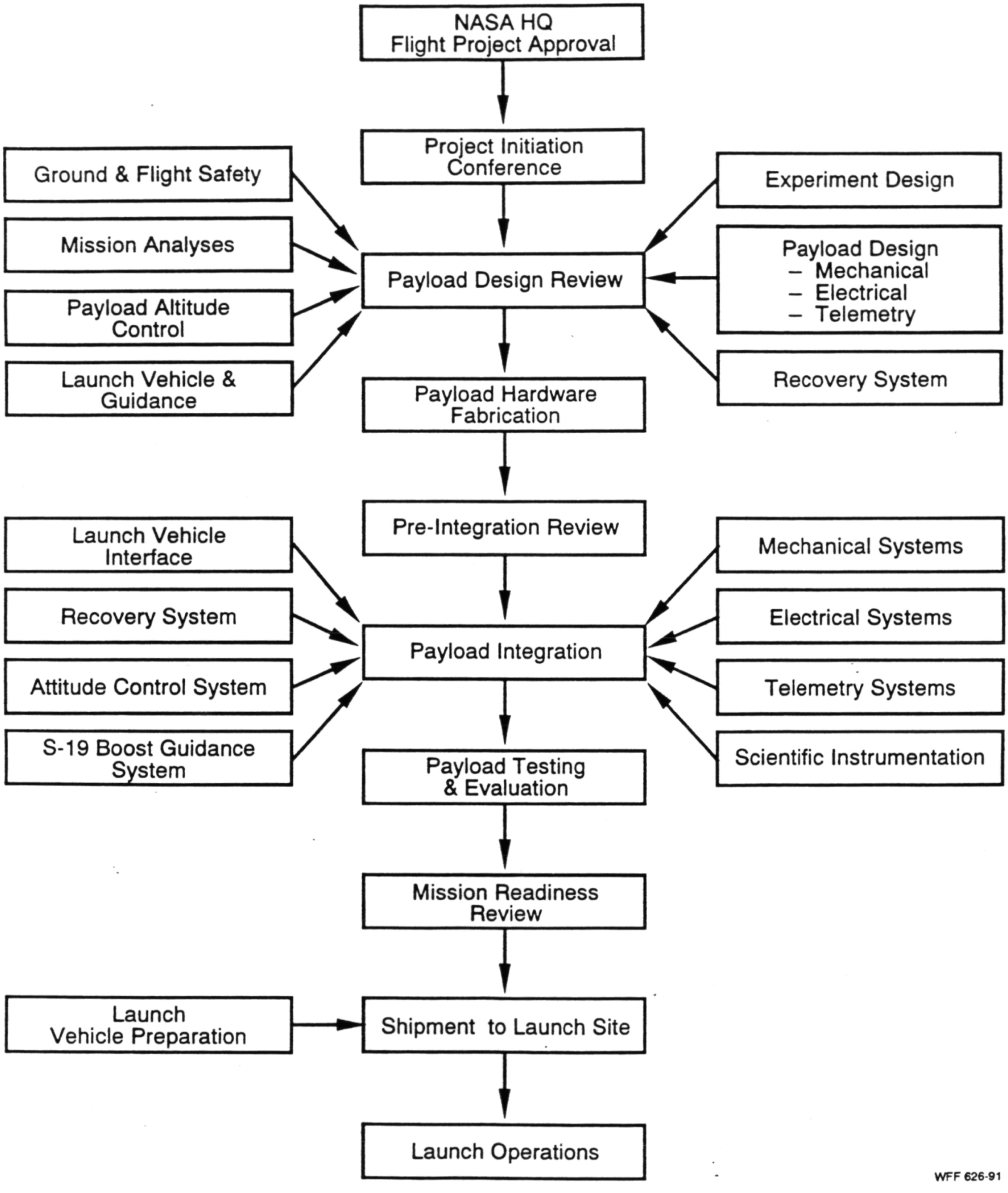
SPECIAL CHARACTERISTICS/REQUIREMENTS OF SOUNDING ROCKET LAUNCH VEHICLES

- **PROGRAMMATIC**
  - **R&D NATURE OF PROGRAM**
  - **WIDE VARIATION IN PERFORMANCE REQUIREMENTS**
  - **QUICK RESPONSE PROJECTS**
  - **SHORT PROJECT LIFETIMES**

- **PAYLOAD INTERFACES**
  - **PAYLOAD VARIABILITY**
  - **PAYLOAD CHANGES**
  - **PAYLOAD PART OF VEHICLE STRUCTURE**
  - **VEHICLE SYSTEMS INTEGRATED INTO PAYLOAD**

- **OPERATIONAL**
  - **UNGUIDED LAUNCH VEHICLES (LARGE DISPERSION)**
  - **LAUNCH FROM TEMPORARY/REMOTE SITES**
  - **LAUNCH FROM FOREIGN RANGES**
  - **FIELD REFURBISH/REFLY**
  - **SPECIAL FLIGHT SAFETY CONCERNS (WIND COMPENSATION)**
  - **SALVO LAUNCH SEQUENCES**

Typical Sounding Rocket Project Flow Diagram

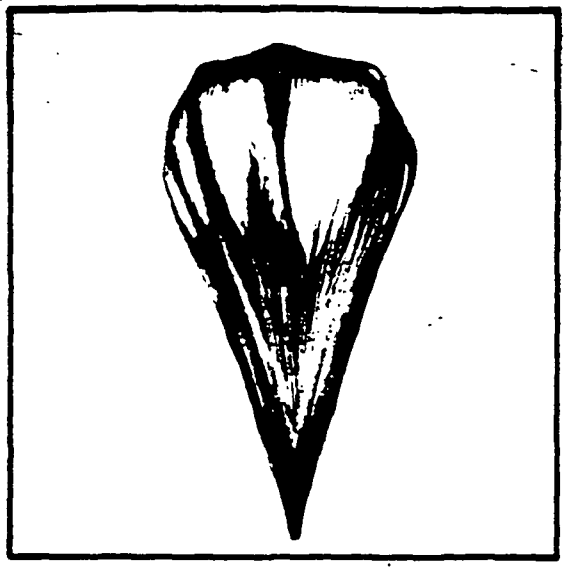


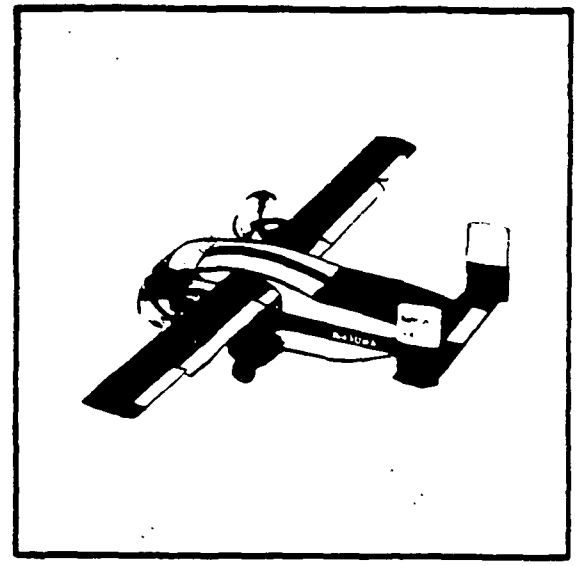
WFF 626-91

NASA SOUNDING ROCKET PROGRAM

VEHICLE SUCCESS

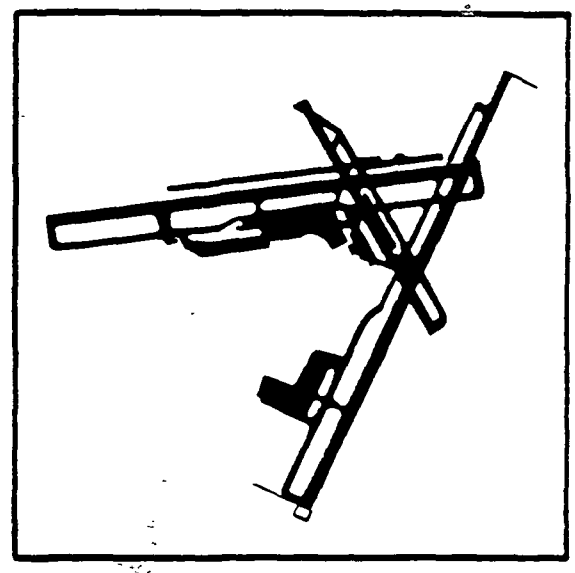
FY	LAUNCHES	LAUNCH SYSTEM FAILURES	SUCCESS RATE %
81	48		100
82	45	1	98
83	53	2	96
84	40		100
85	37	1	97
86	33	2	94
87	29	1	97
88	33		100
89	25	2	92
90	30		100
91	25	1	96
OVERALL	398	10	98

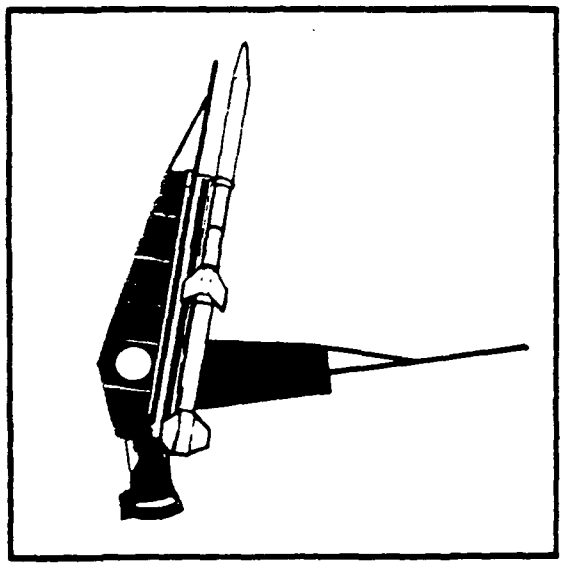


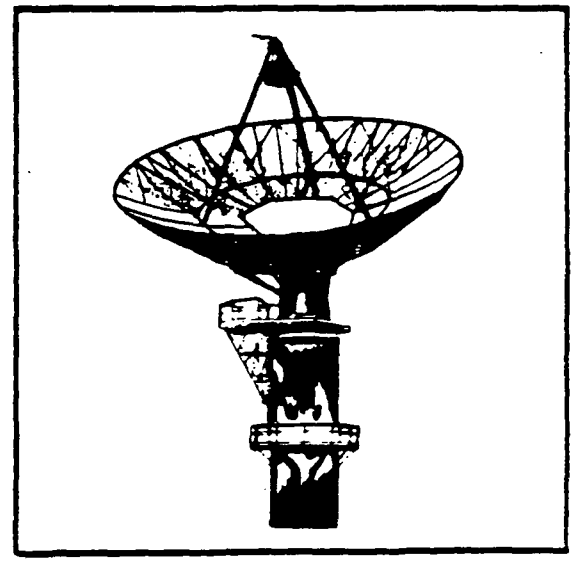


Wallops

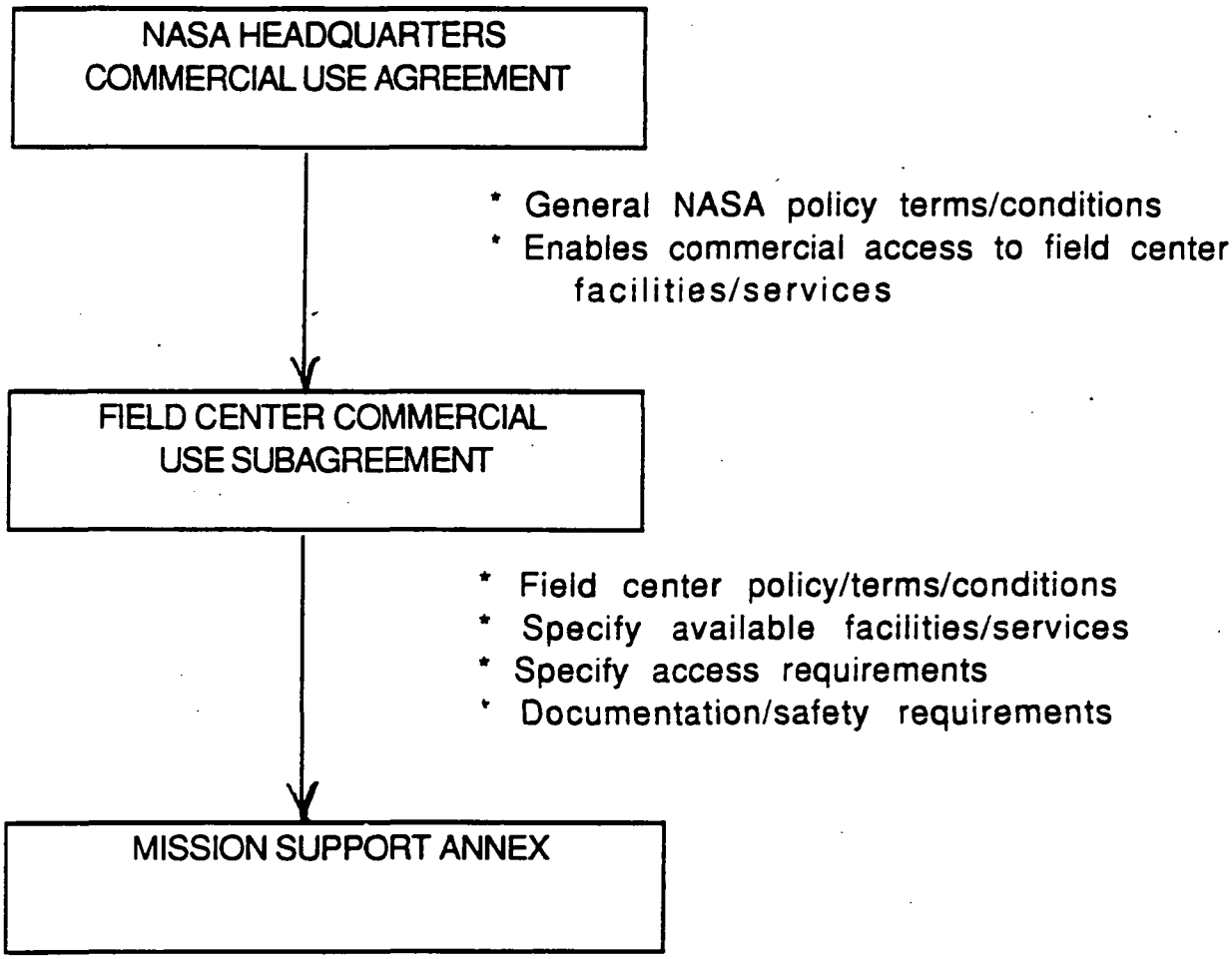
a guide to the facility







NASA AGREEMENT/SUBAGREEMENT IMPLEMENTATION PROCESS



AGREEMENTS/SUBAGREEMENTS
APPLICABLE TO WALLOPS
11/12/91

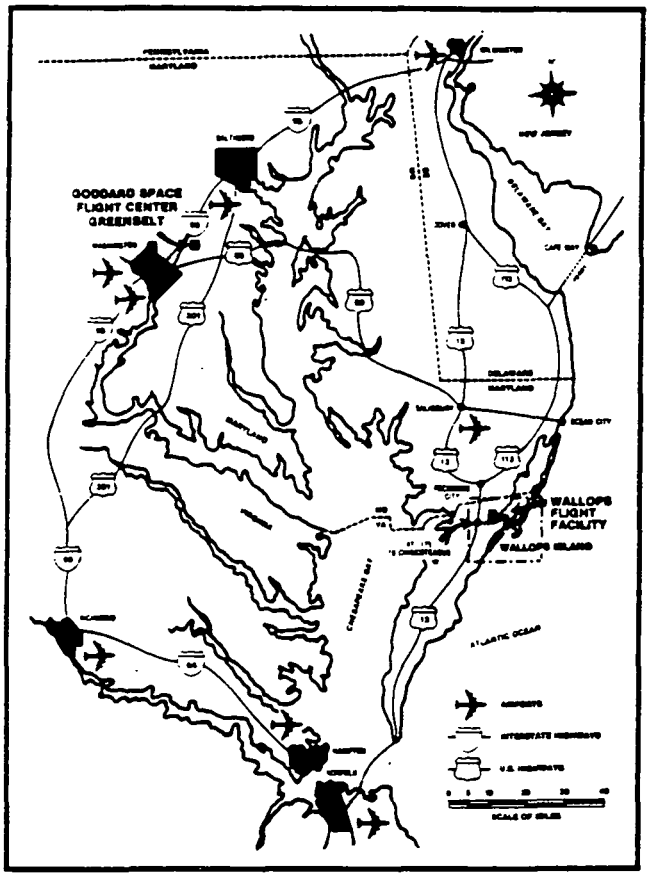
Company/Agreement	Subagreement Status
SSI/EER Agreement (old) Signed 9/4/86 Agreement (new) Signed 3/26/91	-Three launches supported at WSMR. Launch number four in progress. All new support now expected to be requested under new Agreement. -SUBAGREEMENT is required for WFF support and is in review at Headquarters. COMET launch scheduled for late 1992.
LTV Agreement Signed 11/21/88	-Initial discussions held for support activities at WFF. SUBAGREEMENT for support is required. No further progress to date.
Conatec Agreement (old) Signed 5/22/89 Agreement (new) Signed 12/21/90	-Initial discussions held for support at WFF and other locations. No progress to date. All support now expected to be requested under new Agreement. -SUBAGREEMENT is required for WFF support. No further progress to date.
OSC Agreement Signed 7/3/90	- SUBAGREEMENT is required for WFF support and is in review at Headquarters. First launch support scheduled for early 1991.

Geography

The Wallops Flight Facility (WFF) is a part of the NASA Goddard Space Flight Center in Greenbelt, Maryland.

Wallops Flight Facility is located on Virginia's Eastern Shore approximately 40 miles southeast of Salisbury, Maryland, and 150 miles southeast of Greenbelt. Wallops consists of three separate sections of real property — the Main Base, the Wallops Island launch site, and the Wallops Mainland — comprising a total of 6,200 acres and 84 major facilities valued at more than $105 million. Approximately 380 civil service and 560 contractor employees staff the installation with an annual payroll of more than $30 million.

Wallops is comparable to a small town in many respects. For example, it has fire and security protection, water and sewage treatment plants, trash collection, roads, street lights, electrical lines, water and sewage lines, bus service, a library, and a health clinic to operate and maintain, along with other services to the "residents" of Wallops.



Location Map

History

In 1945, the National Advisory Committee for Aeronautics (NACA) added a new dimension to its capability for aerodynamic research at high speeds when it authorized the Langley Research Center to proceed with the development of Wallops Island as a site for research with rocket-propelled models. This step was prompted in large part by the need for extending capabilities for aerodynamic research through the speed of sound and into the supersonic range of speeds with continuous coverage of flow phenomena at all speeds involved. Transonic wind tunnels had not yet been developed, and supersonic wind tunnels were far from adequate for exploration of the many aerodynamic problems that required immediate consideration.

The availability of small solid-fuel rockets and advances in instrumentation made progress possible with a wide variety of experiments that could not be performed using existing research capabilities. The great demand for aerodynamic information of all kinds at continually increasing speeds was met by constant improvement in the techniques for applying rocketry and flight instrumentation techniques to acquire a broad spectrum of scientific and engineering aerodynamic data. Rocketry and instrumentation were considered only as a means to an end, continually being improved and varied to provide a thoroughly coordinated supplement to the constantly advancing capability of ground-based research facilities.

Starting with initial operations in 1945 and continuing throughout the years, Wallops Flight Facility, as a launching site used for science and research purposes, has retained a flexibility and responsiveness to the continually varying requirements of scientific research to achieve important advances in aeronautics and space science. Nearly all requirements for propulsion have been met with relatively small solid rockets staged in various ways to meet the needs of any given research task. The largest and most sophisticated of the launch vehicles has been the versatile Scout four-stage solid-fuel vehicle, capable of launching small scientific satellites, space probes and re-entry missions.

A very important result of the programs carried out at Wallops was effective preparation of the NACA to take on responsibilities as the nucleus

of the National Aeronautics and Space Administration (NASA). The know-how and knowledge stimulated and developed during the research programs at Wallops coupled with NACA research activities with man-carrying aircraft at the Dryden Flight Research Center, Edwards, California, helped prepare the NACA for its subsequent responsibility.

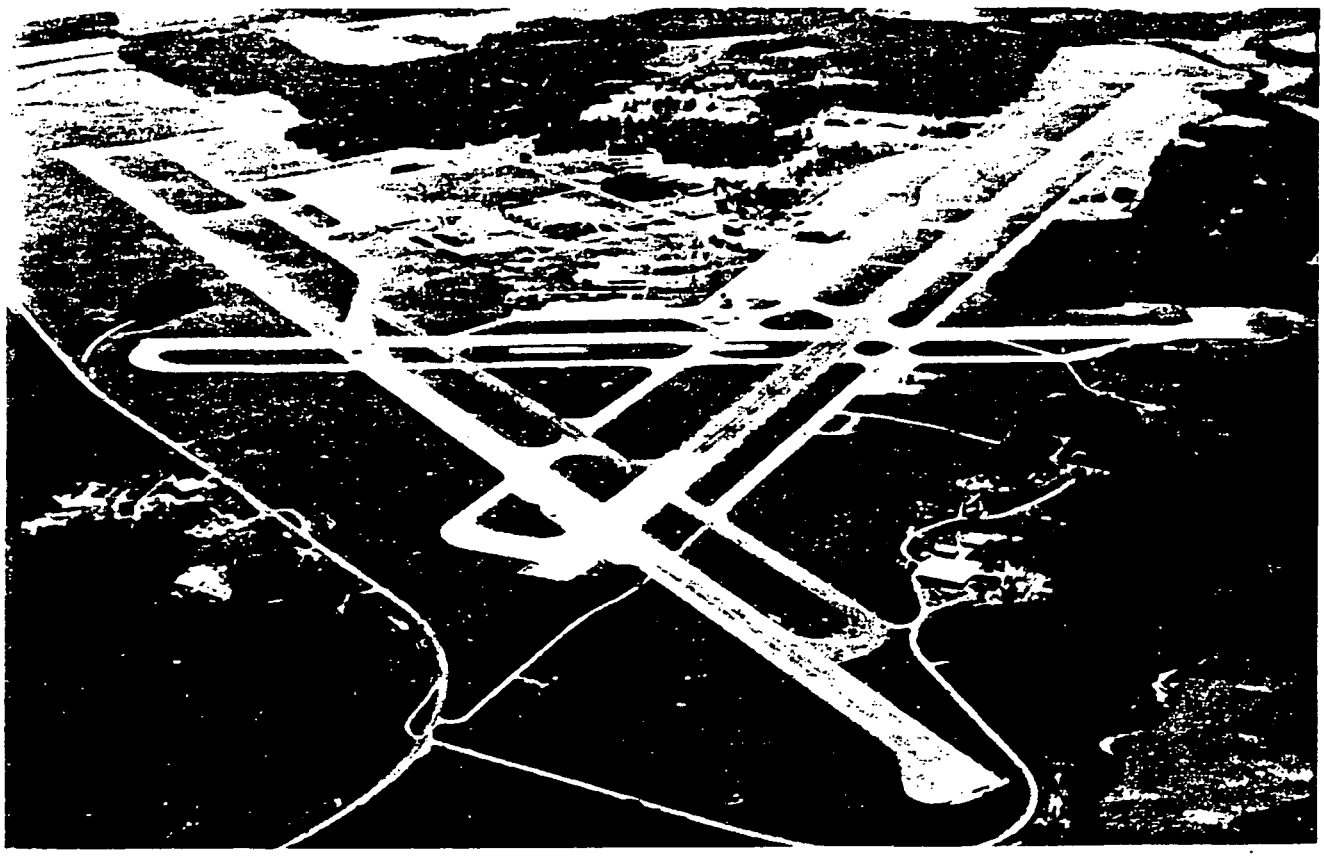
After NASA was established in 1958, the Navy decided to close its Chincoteague Naval Air Station, which was located about seven miles northwest of Wallops Island. In 1959, NASA Wallops expanded and took over these existing facilities, which included buildings, utilities, hangars and an excellent airport.

Today, WFF is at the center of NASA's Suborbital Programs. Sounding rockets, balloons, and aircraft are used actively in NASA programs concerned with space science, applications, advanced technology, and aeronautical research. Missions are conducted locally and throughout the free world.

Twenty-one satellites have been orbited from Wallops since 1961, including the first satellite to be launched by an all solid-fuel rocket vehicle — Explorer IX. Included in these small scientific satellites are micrometeoroid, geodetic, solar, radiation detection, weightlessness on inner ear, stratospheric aerosol, high-energy and astrophysics experiments.

Mission

The primary mission of the WFF is to manage and implement NASA's sounding rocket and balloon programs, to conduct observational Earth sciences studies, to provide aircraft and other flight services, and to operate a launch range and research airport in support of these and other activities. WFF has the diversity of skills and facilities to provide management, design, development, fabrication, testing, operations, tracking, and data acquisition. WFF is committed to provide quick response services that are safe and low cost. When required, Wallops will use its unique resources to support other programs.



Wallops Main Base

Space and Earth Sciences

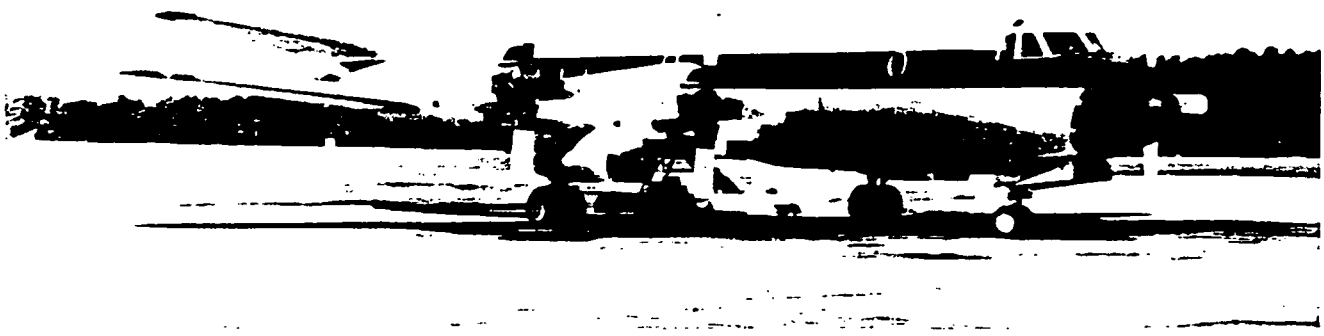
Wallops uses the specialized skills available at this facility to identify, plan, and conduct scientific studies related to NASA Earth Science programs. A description of some of the current research programs follows.

Atmospheric Dynamics - These studies are primarily aimed at increasing the accuracy of measurements used in weather forecasting. Rockets and balloons are regularly launched at Wallops to confirm the calibration and validity of pressure, dew point, wind speed, and temperature measurements. These rocket and balloon measurements also provide calibration of data taken by meteorological satellites. The measurement profiles are compared with satellite readings to determine whether satellite measurements have changed over time due to sensor aging or failure. Sensor correction and measurement quality studies and recommendations are made by Wallops. These help insure the compatibility and accuracy of measurements made by different rockets, balloons, and satellite instruments throughout the world. In addition, atmospheric behavior and structure are studied by this group. In conjunction with other investigators, research is conducted on the interactions between atmospheric electricity and chemistry. This work will contribute to a better understanding of the Earth's atmosphere and its extremely complex nature.

Atmospheric Optics - Experimental and theoretical studies aim at a better understanding of how light interacts with the atmosphere. Processes that occur in the air on Earth receive the most attention, but atmospheric interactions on other planets are also of interest. Programs include laboratory measurements of the scattering and absorption of light by the molecules and particulates (aerosols) that make up an atmosphere. A parallel program develops mathematical models of these processes. Through such projects atmospheric constituents are being measured. For example, two important gasses — ozone and nitric oxide — through their unique interactions with light can now be measured remotely from space and aircraft.

Ocean Physics - NASA Wallops studies ocean physics to monitor and measure such important and diverse variables as ocean wave height and ocean biological activity. New instruments are developed which enable measurements to be made through remote sensing of the oceans by aircraft or satellites. These instruments make direct measurements or are used to acquire complimentary data. Two basic study areas of ocean physics are emphasized, microwave altimetry for ocean surface studies, and ocean color for ocean biology studies.

Microwave Altimetry includes research to determine the average sea surface height over the globe as well as small scale variations caused by currents or gravity effects. Investigations also determine ocean surface currents from satellites and aircraft as well as measurements of ocean surface wave structure.



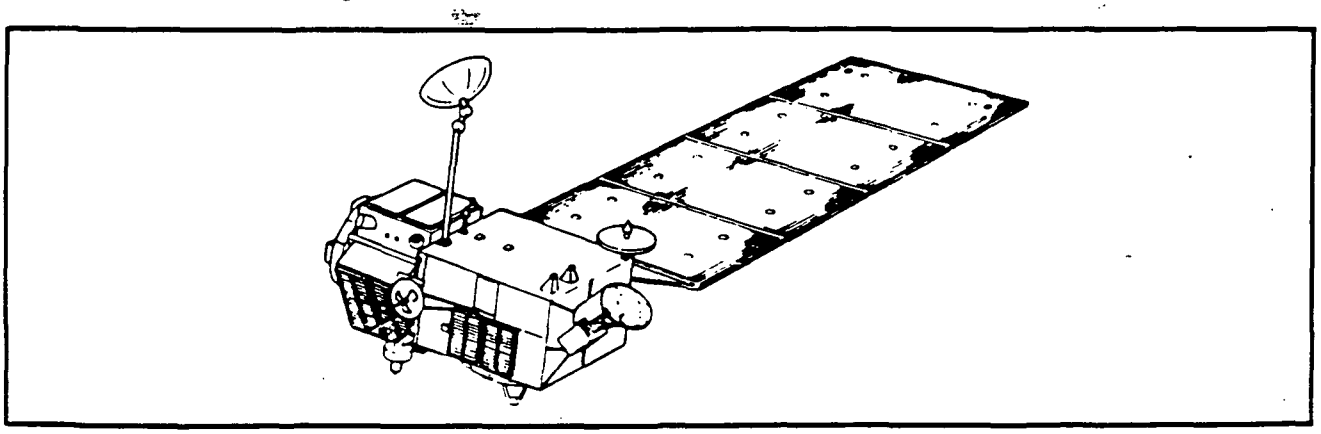
Wallops P-3 Aircraft

These altimeters can also measure land topography. Complimentary instruments precisely measure the location of relative and geocentric positions of well-marked land points. Wallops has developed spacecraft altimeters flown on the Geodynamics Experimental Ocean Satellite (GEOS-3) in 1972, and on the Sea Satellite (SEASAT-1) in 1978. New Wallops altimeters will fly on the Ocean Topography Experiment Satellite (TOPEX) in 1992 and on the Mars Observer Satellite in the 1990's. The Surface Contour Radar (SCR) is another Wallops research instrument which is flown on the Wallops P-3 aircraft.

Ocean Color Research centers on the study of visible and near infra-red (IR) radiation and reflectance from the ocean. This research provides valuable information on biological and physical processes occurring in the ocean and on ocean circulation and sedimentation. The Wallops Airborne Oceanographic Lidar (AOL) is an aircraft research instrument which studies ocean color by two methods. In the passive mode, a 32-channel spectrometer analyzes the light reflected from the ocean due to normal sunlight. In the active mode, a laser is fired downward from the aircraft and the resulting spectrum analyzed. These two modes together aid greatly in the determination of phytoplankton and chlorophyll concentrations and the identification of single-celled plants in the water. This information is also used by other scientists to understand the complete marine food chain of the oceans.

Wind-Wave-Current Interaction - This research is centered around the Wallops 'Wave Tank.' This unique facility is used to study the complex processes that occur at the boundary between earth's atmosphere and oceans. The tank itself is 60 feet in length, 3 feet wide and 4 feet deep, containing approximately 5,000 gallons of water. Environment stimulation machinery can produce winds from 0 to over 50 miles per hour and reversible water current of up to 100 gallons per second. In addition, hydraulic drives can produce a variety of wave patterns from either or both ends of the tank. This facility is one of very few world-wide in which air-sea interactions can be studied under controlled conditions. The facility is highly instrumented by many sensors to precisely measure conditions during experiments. Two mini-computers and a PC-type computer provide control, measurement and data analysis for the facility. Basic research and instrument development are performed by NASA, other government agencies, and universities. Typical research programs include short-wave modification by long-waves, wave interaction on current, rain effects on microwave scattering from the sea surface and gas exchange rates versus radar scatterometer power.

Research Flight Support Activities - NASA Wallops has performed pioneering studies in the use of the Global Positioning System Satellites (GPS) to determine precise location and altitude of research aircraft during experimental flights. This research has provided instrumentation which will define the position of an aircraft and its instruments to less than 10 centimeters (3.9 inches) in latitude, longitude and altitude. Continuing studies will also provide data on motion dynamics to further enhance experiment data. In addition, through the Navigational and Environmental Measurement System (NEMS), instruments are available to provide information on outside air temperature, dew point and pressure, as well as precise aircraft roll and pitch attitude, and vertical acceleration.



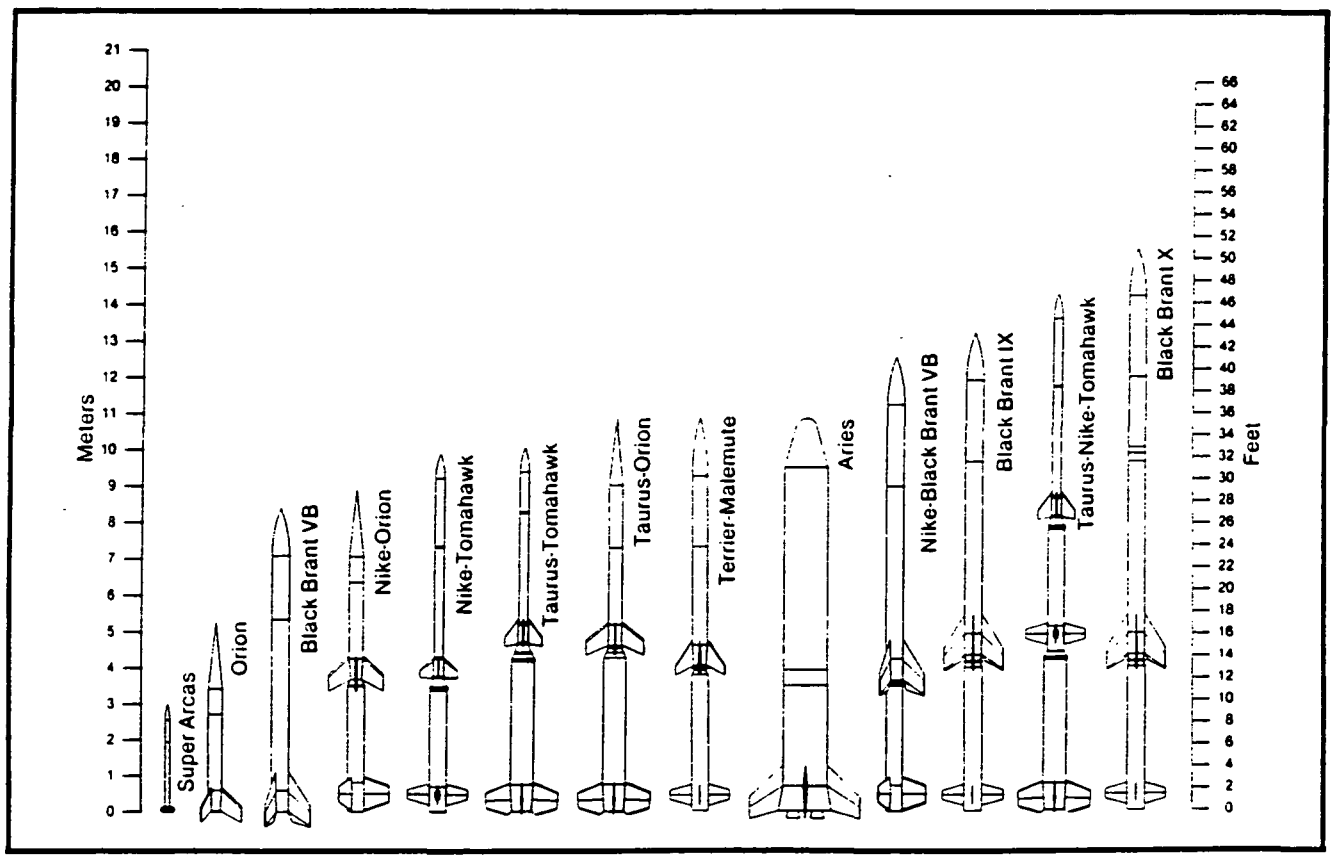
Topography Experiment Satellite (TOPEX)

NASA Sounding Rocket Program

The NASA Sounding Rocket Program, managed by Wallops, provides sounding rocket launch vehicles which carry research payloads with scientific instruments to altitudes ranging from thirty miles to approximately six hundred miles (three to four times higher than the space shuttle). The experiment time above the Earth's atmosphere ranges up to 15 minutes. Scientific data are collected and usually returned to Earth by telemetry links. Parachutes often are used to recover the instruments for reuse and special high-altitude parachutes sometimes are used to retard descent velocity so that experimenters have more time to gather data at high altitudes.

Sounding rockets provide the only means of making in-situ measurements at altitudes between the maximum altitude for balloons (about 30 miles) and the minimum altitude for satellites (about 100 miles). The Sounding Rocket Program serves not only NASA but other government agencies, universities, industry, and foreign countries as well. The program is, by design, a low-cost, quick-response activity when compared to Agency orbital missions.

The sounding rocket allows space scientists to conduct investigations at a specified time and place. The experiments provide a variety of information, including high altitude wind shear and velocity; density and temperature of particles in the upper atmosphere; properties and changes in the ionosphere, the natural radiation surrounding the Earth; and data on the Sun, stars, galaxies, nebulas, planets, and many other phenomena. Atmospheric scientists use sounding rockets to investigate the chemical makeup and physical processes taking place in the atmosphere, while scientists in the field of plasma physics investigate the energetic particle population in space and in the Earth's atmosphere. Sounding rockets assist both solar scientists' investigations of the Sun and its makeup, physics, variability, and its effect on the Earth, as well as scientists' studies of the universe outside the solar system to better understand its origin and the processes that occur there. Many graduate students are supported by and earn their degree based on their participation in this original research. Sounding rockets also are used to test and develop devices and instruments for orbital flight.



NASA Sounding Rockets

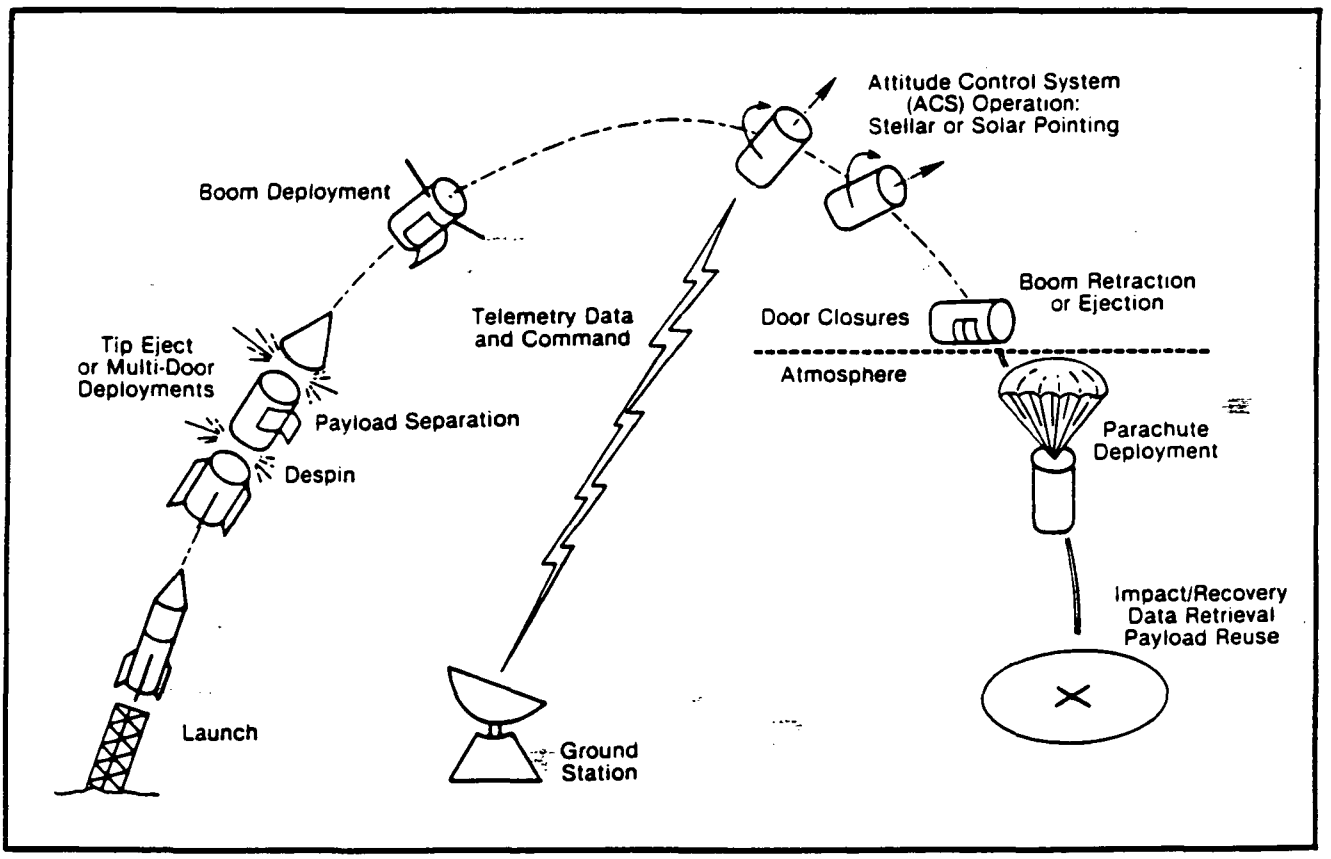
Thirteen different systems currently are included in the launch vehicle stable to provide the performance requirements necessitated by various experiments with diverse weight and altitude requirements. Payload weights have grown to 2,500 pounds, and payload diameters have increased to 44 inches. A significant characteristic of the Sounding Rocket Program is the inherent capability to respond quickly to scientific requirements with launch operations practically any place on Earth using either permanent or mobile range facilities.

Sounding rockets routinely are launched from established ranges such as Wallops Island, Virginia; Poker Flat Research Range, Alaska; White Sands Missile Range, New Mexico; and sites in Canada, Norway, and Sweden. Sounding rockets can be launched from temporary ranges when there is a need. Launch expeditions have been conducted from locations such as Punta Lobos, Peru; Rio Grande, Brazil; Keweenaw, Michigan; Red Lake, Canada; Cape Parry, Northwest Territory, Canada; Puerto Rico; Point Barrow, Alaska; Søndre Strømfjord, Greenland; Siple State, Antarctica; Alice Springs, Australia; and even an aircraft carrier in the Pacific Ocean.

Wallops interfaces with NASA Headquarters, other government agencies, universities, private industry, and the international community. Wallops provides engineering support for the Sounding Rocket Program including feasibility studies, payload design and development, vehicle engineering, attitude control systems engineering, payload recovery systems engineering, and test evaluation engineering.

Wallops also provides mission and payload management for the rocket program's flight projects. Wallops personnel develop and maintain computer programs for analytical studies and data analysis pertaining to the facility's functions. Financial support for principal investigators is also provided through the Sounding Rocket Program.

The Sounding Rocket Program currently supports 40 to 45 launches each year. Approximately 2,500 missions have been conducted since 1959 with an 86% mission success rate for that period and an 89% mission success rate for over 200 missions in the last five years.



Sounding Rocket Example Mission Profile

NASA Balloon Program

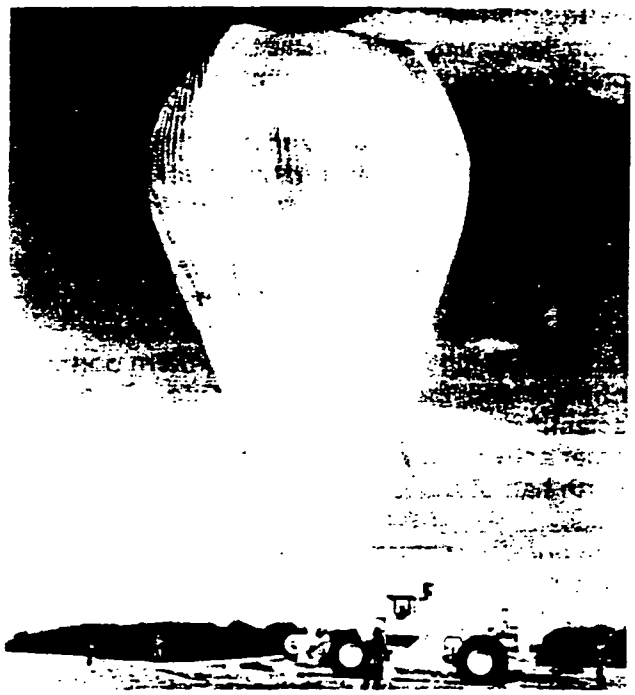
Wallops manages the NASA Balloon Program, including management of NASA's National Scientific Balloon Facility (NSBF) in Palestine, Texas. Balloons provide platforms to carry research payloads with scientific instruments to make measurements at altitudes up to 30 miles. Balloons provide much longer flight times than sounding rockets without the rigors of rocket liftoff, vibration, and G-forces, and, therefore, permit laboratory quality equipment to be flown. Through NSBF, Wallops provides balloons, helium, and operational support for launches from many sites including Palestine, Texas; Fort Sumner, New Mexico; Holloman Air Force Base, New Mexico; Laramie, Wyoming; Barking Sands, Hawaii; Poker Flat Research Range, Alaska; Ainsworth, Nebraska; Wallops Island, Virginia; and from foreign countries including Australia, Canada, and Brazil. Wallops provides the technical direction of the program, the research and development support for ballooning, and selected tracking and data acquisition and data processing in support of balloon flights.

Balloons are made of a thin, polyethylene material .8 mil thick and up to 30 million cubic feet in volume at full inflation, but they have historically varied in thickness from .5 to 1.5 mil and up to 50 million cubic feet in volume. Payloads up to 5,500 pounds can be accommodated, and flight durations may vary from 1 to 60 hours. A new capability in the form of long duration flights of up to two weeks is under development. A tethered balloon system also is used and can carry a 400-pound payload to one mile altitude.

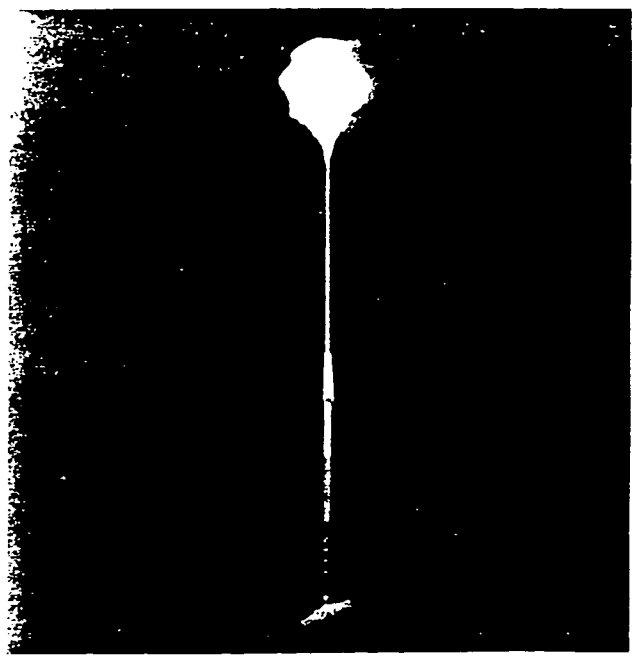
The Balloon Program offers capabilities and benefits for scientific research that cannot be duplicated by other research methods. Balloons provide measurements in areas too low for sounding rockets or satellites and too difficult for aircraft which cannot sustain flights for long periods or reach the required heights. The scientific payloads are furnished by the individual investigators and routinely are recovered for reuse of scientific instruments.

The use of balloons allows for multi-disciplinary experiments, vertical profile measurements, and scientific measurements at a specific altitude at a specific time or measurements at multiple locations over a particular time period. Balloons also allow for satellite data verification using systems launched in coordination with orbital coverage and for flight testing of materials, instrumentation, and experiments destined for future space missions.

The Balloon Program currently supports approximately 45 launches each year. Between 1976 and 1986, 493 balloons were launched with an overall success rate of 85%.



Inflating balloon prior to launch



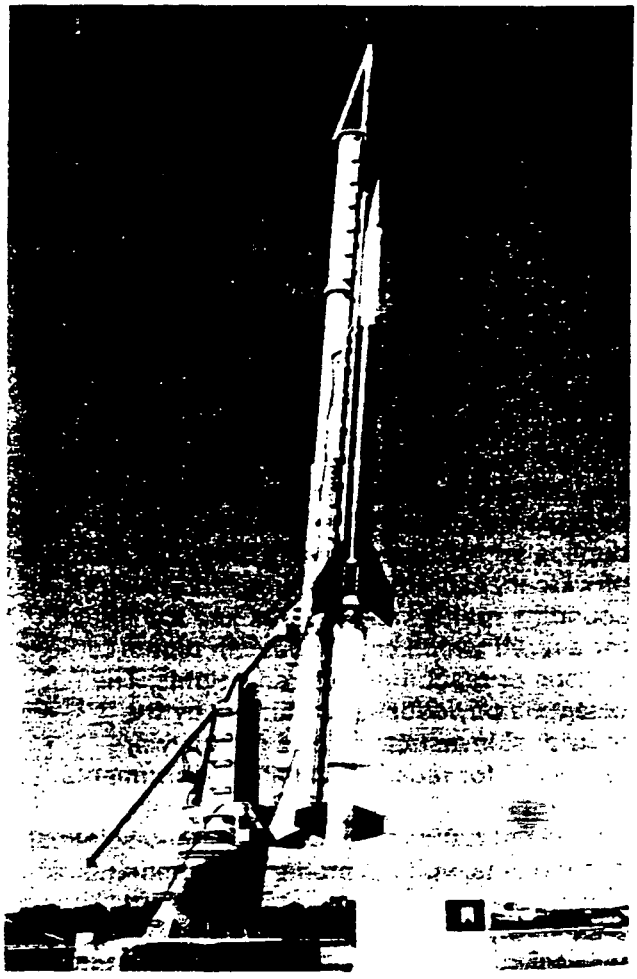
Balloon in flight

WFF Launch Range

The Wallops launch range is based on Wallops Island and extends out into the Atlantic Ocean using the surface area and airspace above to conduct various flight operations. The principal Island facilities are those required to process, check-out, and launch solid rocket boosters carrying scientific payloads on suborbital or low Earth-orbit trajectories. Included are launch pads, launchers, blockhouses, booster preparation and payload check-out buildings, dynamic balance equipment, wind measuring devices, communications and control instrumentation, TV and optical tracking stations, surveillance and tracking radar units, and other supporting facilities. Because the launch areas are located on the southern half of Wallops Island, most of the facilities mentioned here are in that area also, with special use facilities being located on the northern portion of the island. From time-to-time, ground-based scientific equipment requiring isolation from other activity may be located temporarily on the north half of the island.

The primary mission for the WFF launch range is to provide a safe and efficient site for the conducting of NASA sounding rocket operations and to provide an east coast base for launching the NASA Scout rocket booster, a large expendable launch vehicle built by LTV and used primarily to place small spacecraft into low Earth-orbit. Facilities on Wallops Island are used, as required, to support other NASA science and research programs, which may involve the use of small meteorological rockets or balloons to carry instruments to desired altitudes. In addition to support of NASA programs, the launch range is used for rocket and non-rocket programs of other U.S. government agencies, where such use does not impact on the NASA-sponsored activities. Typical other-agency programs supported include: VANDAL, a high speed target missile for the Naval Air Test Center; sounding rockets for the Air Force Geophysics Laboratory; and full-scale aircraft development programs for the Naval Air Test Center.

The principal work performed by the technicians who staff the facilities on Wallops Island fall into two phases; the preparation process and the countdown activity. During the former, the tasks performed by the launch crew have to do with the assembly and checking of the accessories (fins, interstage hardware, etc.) and the rocket motors, mating the payload to the assembled rocket vehicle, and placing the entire system on the selected launcher and performing preliminary tests to validate the integrity of the combined vehicle/payload systems. During the "countdown," the launch crew and payload team perform final checks of their respective systems and place them in a liftoff/flight configuration. As the countdown activity gets underway, other units of the launch range — including telemetry, radar, communications, and safety systems — are brought on-line to provide necessary support for the pending flight mission. A key element in this process is the Range Control Center, located on the main base, which functions to provide the overall control and direction of the countdown operations. From that location, the Test Director leads all the range elements through a step-by-step procedure for the orderly performance of a variety of preparatory tasks, satisfactory completion of which are required before the "go-for-launch" authorization can be given.



Black Brant IX on launcher

The Range Safety Officer monitors launch area operations, computes the wind profile and launcher settings, keeps track of ships and aircraft in the operating area, and follows the course of rocket flights. After the rocket leaves the launcher, radar and telemetry instrumentation systems track the flight of the rocket system and payload, recording the trajectory data and receiving and storing the experimental data, which typically is transmitted from the payload throughout the flight. Some of the payloads descend by parachute and are recovered either in mid-air by an aircraft or from the ocean surface by boat or helicopter.

Frequently, there are science objectives which only can be met by performing flight missions from locations distant from any established launch site. To support such rocket and balloon missions, WFF maintains a mobile launch facility which can be moved readily by aircraft or ship to the remote location and setup to provide essentially the same launch range capability which exists at Wallops. This mobile launch facility, which consists primarily of large vans and trailers, containing the essential preparation, check-out, launch, and tracking equipment, has supported the sounding rocket program at a variety of remote sites in both North and South America and Greenland. Individual elements of the mobile range, primarily the radar and telemetry vans, have been used to meet other rocket and balloon requirements at locations around the world.

Research Airport

The WFF Research Airport, wholly-owned and operated by NASA, provides a broad coverage of communications, telemetry, enhanced radar tracking, flight path guidance, and other supporting services to a variety of aeronautical research programs dealing principally with the aircraft/airport interface. The airport, orginally the Chincoteague Naval Air Station constructed during World War II, is equipped to provide the vital normal aircraft services. A control tower is in operation during working hours.

One of the three airport runways has been specifically modified for aircraft traction studies. This research runway has several sections made up of different surface materials and with grooved and ungrooved areas. These sections may be flooded with water and the depth controlled to within 1/10 inch. This same runway has a Microwave Landing System (MLS) installed. The MLS — the instrument landing system of the future — has been a joint research and development effort by the Federal Aviation Agency, the Department of Defense, and NASA. The MLS currently is being used by research projects developing systems technology and flight procedures for aircraft that will use the MLS to make automatic all-weather landings. The runway also is equipped with a high-speed turnoff where techniques are studied that will provide guidance information to aircraft, permitting them to exit automatically from runways at high speed.

Aircraft landing on flooded research runway

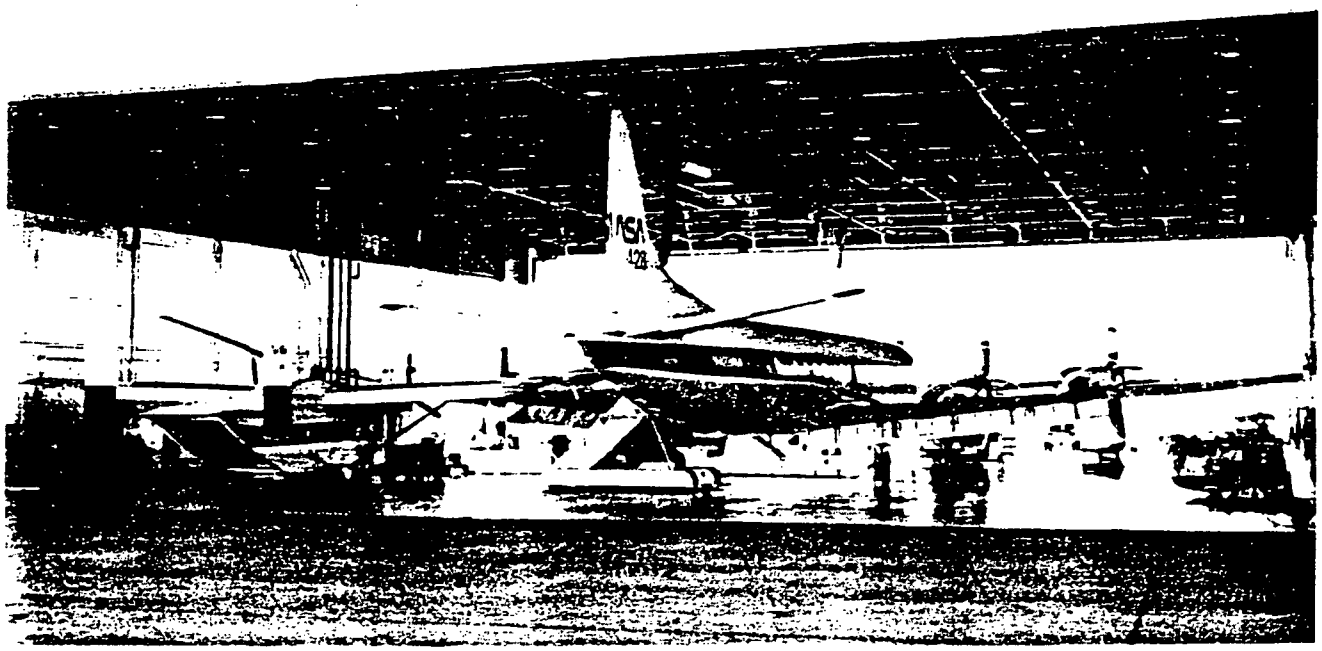
Other aeronautical research efforts at this sea level airport are concerned with environmental effects (usually noise), engine water ingestion, and safety and operating problems. One program is associated with a research effort to improve the stall/spin characteristics of general aviation aircraft and thereby enhance the safety of flight. Most of the projects orginate at other NASA centers, primarily the Langley Research Center at Hampton, Virginia; other government agencies, such as the Federal Aviation Agency; the military services; and a few from private industry.

Hangar space for the aircraft and laboratory space for the research teams are made available in hangar N-159 to the visiting aeronautical research programs. An Aeronautical Project Control Center is located in building A-1 just below the control tower. Here, all of the operational elements required to support aeronautical research tests are coordinated and controlled. Communications, information, and data are transmitted by radio and land lines, and the controllers are able to oversee visually all of the airport's operational area. The airspace surrounding the airport and the restricted airspace extending from the airport to the offshore warning areas are controlled from the tower and can be closed to other aircraft when necessary.

Aircraft Airborne Science

Some of the WFF aircraft are used as research platforms for scientific missions. Helicopters and several fixed-wing aircraft provide a variety of flight performance and payload-carrying ability. Science missions are conducted locally and on a regional or global basis.

The helicopters offer support for small scientific instrument packages which need to operate at low speeds and low altitudes. A twin-engine turboprop Skyvan aircraft with its large rear opening is easily configured for conducting local and regional research missions. One larger four-engine aircraft with nadir and zenith viewing ports and a large unpressurized bomb bay compartment is ideally suited for carrying complements of large scientific instruments for conducting oceanographic and ice research missions. Another four-engine aircraft, similarly modified with upward and downward viewing ports, has evolved into an excellent platform equipped with large complements of in-situ and remote gas samplers for conducting air chemistry research missions. Both of the large turboprop aircraft can carry scientific payloads of more than 10,000 pounds and often are deployed to foreign country bases from which missions are flown to underfly satellites and/or study scientific phenomena peculiar to specific sites. A T-39 high



Wallops aircraft in Building D-1 Hangar

altitude turbojet aircraft is used to take payloads of 1,200 pounds or less up to altitudes of 40,000 feet for research in the lower stratosphere, making comparisons with satellite derived information and for the development of instruments for future satellites.

A potential user of the aircraft can expect to receive support in planning his or her mission, in adapting and installing the instrumentation on the WFF aircraft, in obtaining the necessary flight clearances (both foreign and domestic), and in establishing additional support or logistics required for mission success. The operational policies of the WFF aircraft fleet have been developed over the years to facilitate the use of the aircraft for the user with a minimum of difficulty, but always with safety of flight as the first priority.

The scientific groups which use the WFF aircraft as research platforms come from several NASA centers, other government agencies, the academic community, and, occasionally, foreign countries.

Aircraft Fleet

WFF operates a fleet of six program support and one administrative aircraft. The aircraft range in size from a single engine small helicopter to a four-engine Lockheed Electra. The program aircraft are used to provide radar surveillance of offshore rocket impact areas to protect shipping and fishing boats; midair recovery; search for payloads to be recovered from the ocean surface; relay radio signals over the horizon; search and rescue and other flight support for aeronautical research programs; and as research platforms for scientific payloads.

The WFF aircraft fleet is operated, maintained, and managed by highly-qualified flight crews and personnel with the goal of providing efficient and safe airborne operations.

Tracking and Data Acquisition

Tracking and data acquisition activities at Wallops are covered by three functional areas: radar, telemetry, and data systems, including communications and optics. These activities support the full range of sounding rocket, balloon, and aeronautical research and development and scientific experimentation. Similar capabilities can be configured to support mobile operations worldwide. In addition, WFF has a satellite tracking facility as an integral part of the station telemetry capability.

Radar - Radar systems track sounding rockets, balloons, satellites, and aircraft to provide accurate velocity and positional data. Some targets are tracked by using the radar signals which are reflected from the target. This is called "skin tracking." Some targets carry a beacon which responds to the incoming radar signals by replying with a transmitted signal which is received and measured by the radar system. The range of support provided by radar systems at Wallops can vary from working with local aircraft in the vicinity of Wallops airport to tracking distant objects in space. Radar capabilities can be enhanced by laser tracking systems and sophisticated data processing systems to improve the precision and record, analyze, and process radar data. Some Wallops Flight Facility aircraft are radar equipped to support experiments and operations by providing range surveillance and tracking. The systems operate in the UHF, X, S, and C frequency bands.

Wallops Range Control Center

Telemetry - Telemetry is the technology most frequently used to acquire data from experimental instruments carried aboard satellites, space vehicles, sounding rockets, balloons, and aircraft. Data from the experiment are encoded and radioed to an Earth station for recording and analysis. Both analog and digital techniques of data transmission are used. Almost all systems operate with S-band (2200 to 2300 Megahertz [Mhz]) down-links and 550 Mhz up-links. A frequency of 1680 Mhz is used occasionally for down links on some of the smaller sounding rockets.

- Telemetry data systems have the capability of providing positional data for the target.

At Wallops Flight Facility, there are two 24-foot automatic trackers and two eight-foot automatic trackers. These are supported by antenna control and receiving stations, four readout Pulse Coded Modulation (PCM) stations, a digital PCM station, and a meteorological station.

FPQ-6 Radar on Wallops Mainland

Data Systems, Communications, Command and Control

Data Systems - Data are acquired during operations from radar, telemetry, optical, meteorological, timing, and communications systems. This data are processed by various computers at Wallops to provide vital information to experimenters and to support operations. A variety of data systems acquire, record, and display information in real time for command, control, and monitoring of flight performance.

Communications - Wallops Flight Facility operates ground-to-ground, air-to-ground, ship-to-shore, and intrastation communications systems. These systems are composed of radios, cables, microwave links, closed-circuit television systems, command and control communications, frequency shift tone keying systems, operational teletype systems, high-speed data circuits, and the WFF NASA Communications (NASCOM) Network terminal. Satellite communications and fiber optics are in growing use.

These systems provide the means for managing operations at Wallops and communicating and coordinating with related operations in other geographic areas (*e.g.* providing communications and tracking support for Space Shuttle operations at Kennedy Space Center).

Command/Destruct - A command/destruct system allows ground control of airborne vehicle (sounding rocket, balloon or aircraft) functions of on-board experimental devices. In the case of sounding rockets and balloons, the Range Safety Officer can terminate some flights in the unlikely event a malfunction presents a range safety hazard.

Optics - Optical systems play an important part in operations at Wallops. Remotely-controlled television cameras monitor range operations and provide safety related information. Tracking cameras, including both film and a long-range video tracking system, provide visual information from remote locations for project and range support.

Control Centers - Both control centers located at Wallops are on the Main Base. The Airport Project Control Center controls experimental activities of aircraft using Wallops Airport. The Range Control Center controls both launch and tracking and data acquisition operations.

The control centers are focal points for communications, operational management, and range safety. Vehicle operations, tracking and data acquisition are controlled, and performance data are displayed on plotboards and video monitors. Instantaneous communications with all participants in a mission provide the means for coordinating complex operations.

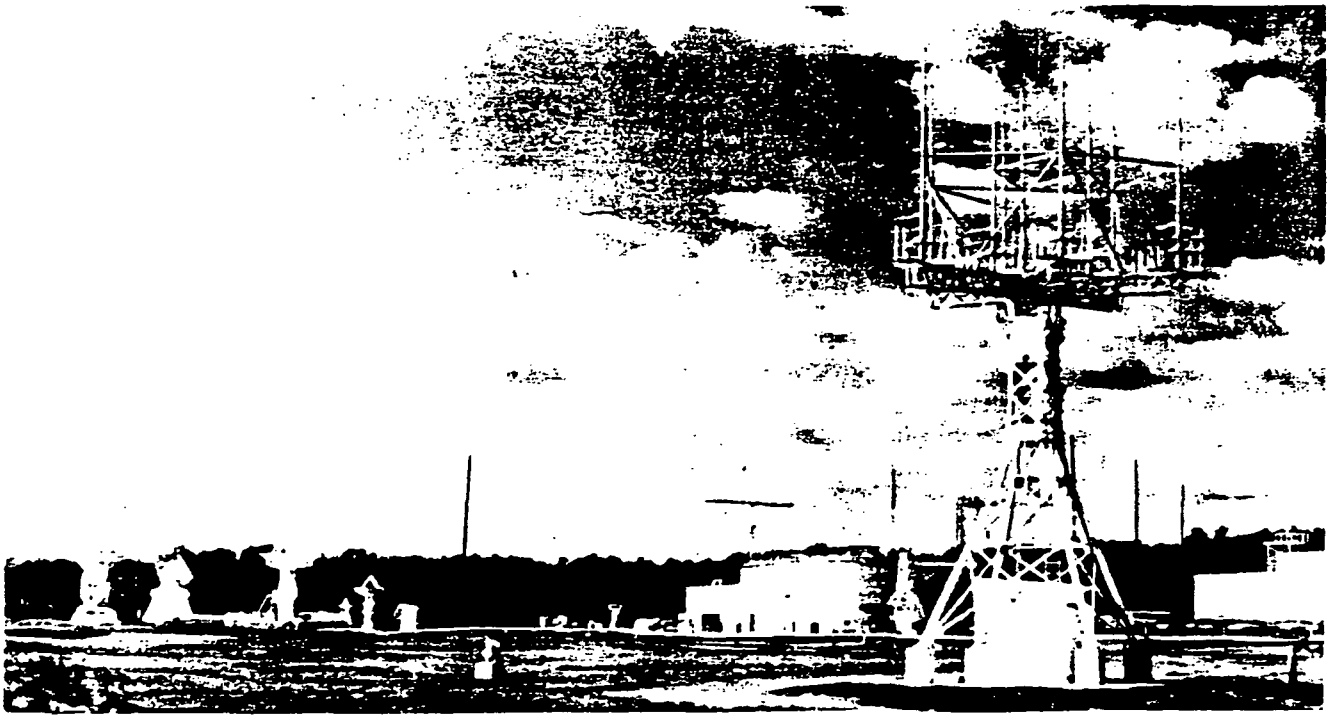
Airport Project Control Center

Mobile Systems

Wallops Flight Facility supports balloon and sounding rocket campaigns in other areas of the world. Campaigns have been conducted in Arctic and Antarctic regions, South America, Africa, Europe, Australia, and even at sea aboard a ship. To provide radar, telemetry, and data system support — simiar to capabilities permanently available here — mobile equipment has been developed which can be transported to where it is needed. These transportable facilities are self-contained with their own power, heating, and cooling. Personnel from Wallops Flight Facility usually accompany the equipment and may spend several months operating at these remote locations.

Wallops Orbital Tracking Station

In 1986, the Wallops Orbital Tracking Station was established. This ground-based satellite tracking and telemetry station acquires telemetry from satellites to support several important programs which include: the International Ultraviolet Explorer Satellite (IUE), the Interplanetary Monitoring Platform Satellite (IMP-8), the Nimbus-7 Meteorological Research Satellite, and the future Cosmic Background Explorer Satellite (COBE). High-speed data transfer to Goddard Space Flight Center at Greenbelt is provided by a satellite communications link.



Wallops Orbital Tracking Station

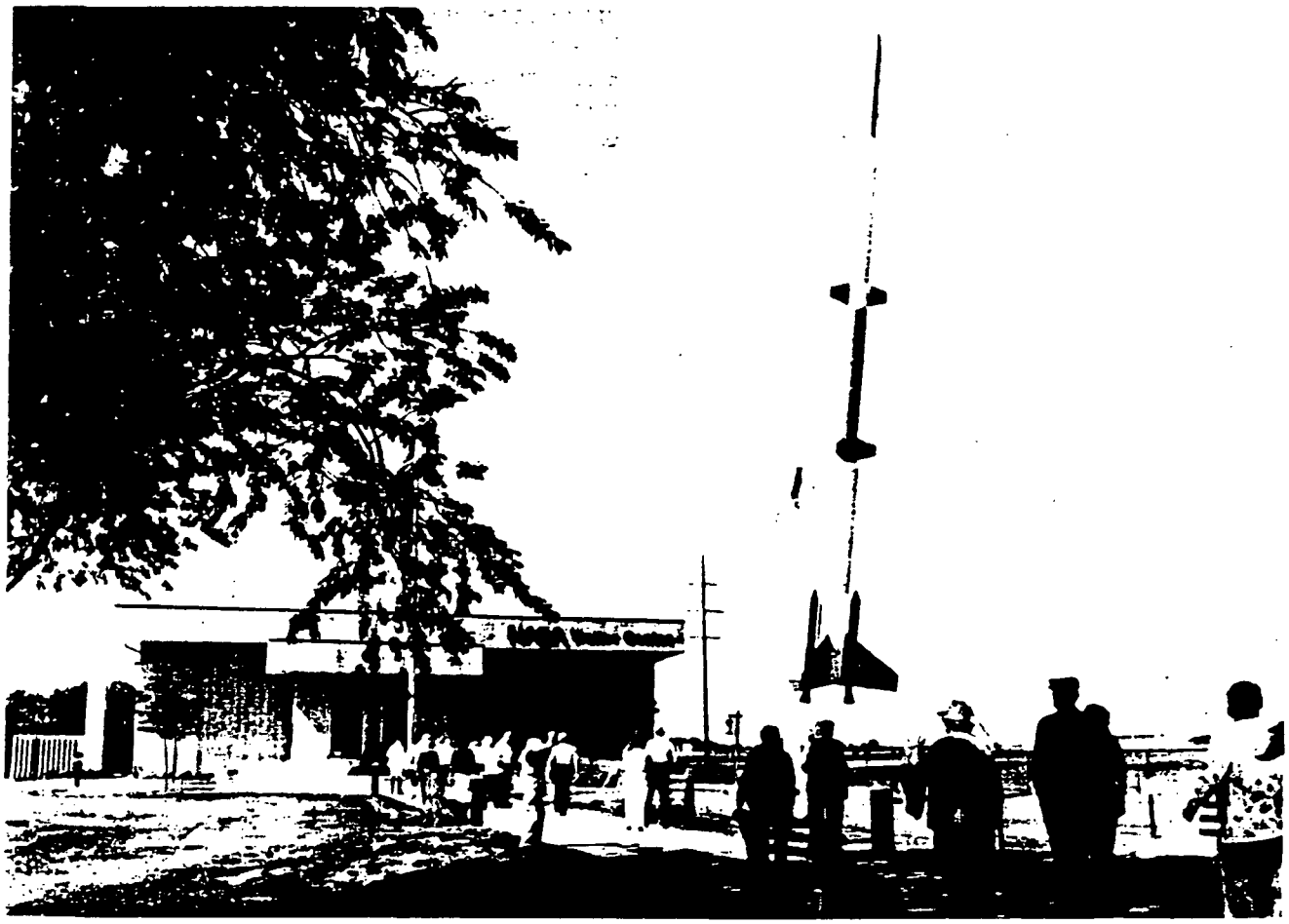
C-2.

Support of Others

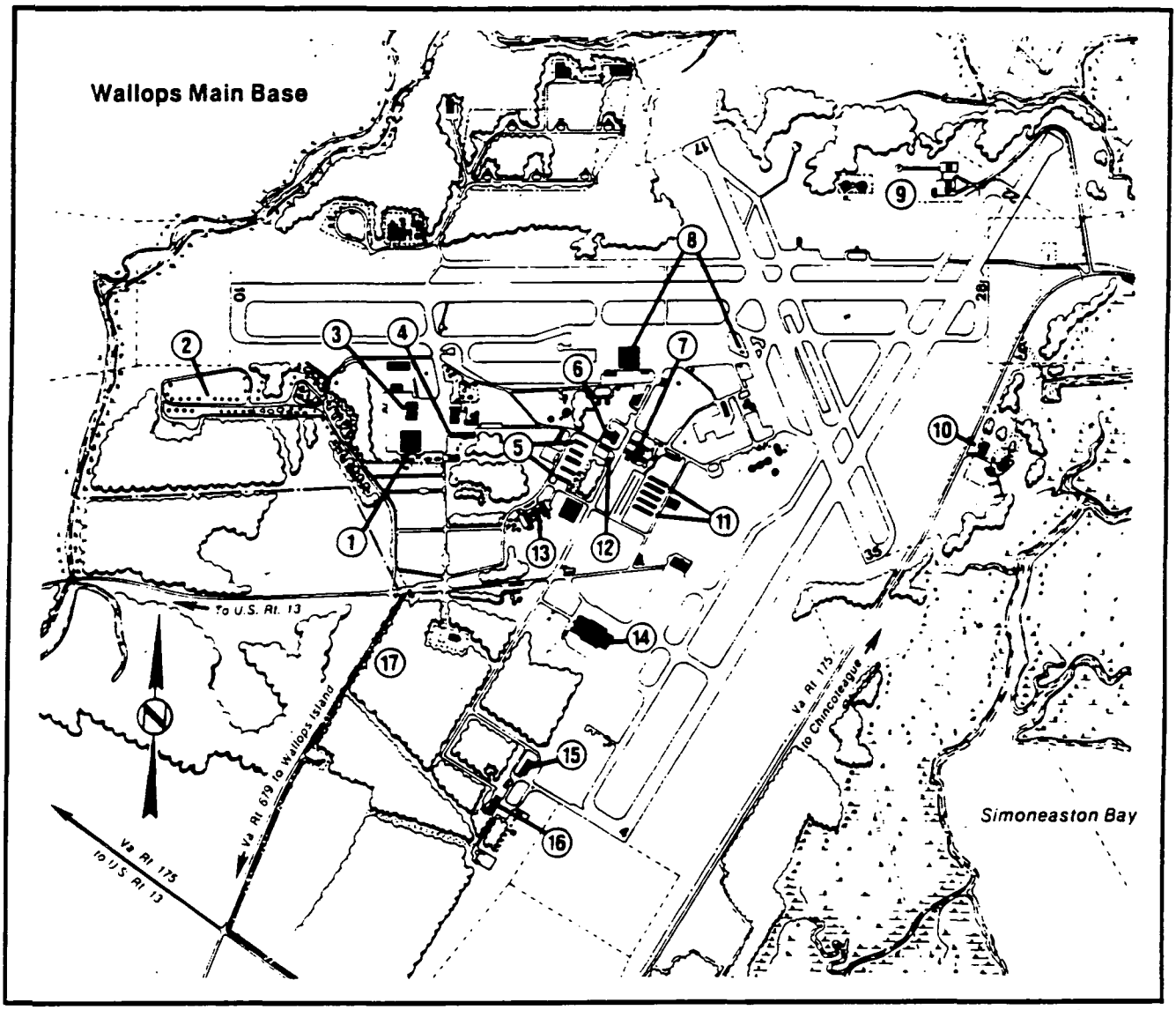
The unique resources at Wallops are used to support the programs of other agencies, non-profit laboratories and commercial space ventures. The use of the Wallops facilities contributes to research that benefits the space program, aeronautics, transportation, agriculture, fisheries, and other industries, as well as national defense. Elements of the Navy, Coast Guard, and NOAA are tenants on the Wallops facility that share the use of the facilities and services available. Some commercial corporations currently use the spin balance facilities, and others plan to use the launch facilities in the future.

NASA Wallops Visitor Center

The Wallops Visitor Center (VC) is located on Route 175 across the road from the Wallops runways about six miles from Route 13 and five miles from Chincoteague, Virginia. It houses a collection of spacecraft and flight articles, as well as exhibits about the history of manned flight, Wallops' research activities and other NASA research projects, with an emphasis on Wallops. Special movies and video presentations also can be viewed. There is a gift shop with space souvenirs, and refreshments may be purchased at the vending machines building. Guided tours of the Wallops' facilities are available to organized groups — including school and civic organizations — and tour groups. Each tour is designed to meet the educational level and interest of the group members. Special programs, which range from lectures and exhibits on NASA programs to monthly model rocket demonstrations, are held throughout the year. The Visitor Center is open daily for self-guided walk-through tours from 10 a.m. to 4 p.m. each Thursday through Monday (closed Tuesday and Wednesday) and on Federal holidays except Thanksgiving, Christmas, and New Years' Day. More than 50,000 persons visit the Wallops Visitor Center annually.



NASA Wallops Visitor Center



Wallops Main Base Legend

1. **Building F-10** - Fabrication and integration laboratories where sounding rocket payload systems are designed, fabricated, integrated and environmentally tested are located here. The environmental tests subject the systems to vibrations and acceleration levels comparable to what they will experience during rocket flight.

2. **Coast Guard Housing** - Families of the Coast Guard Eastern Shore Group occupy 25 houses in this area, which was formerly part of the Main Base.

3. **Building F-16** - The technical services shop building contains the carpenter, paint, electric, and welding shops; the garage; and the plant operations offices.

4. **Building F-7** - Logistic branch personnel, stock control, shipping and receiving, travel office, and vehicle control are located here.

5. **"F" Buildings** - Buildings F-5 and F-4 are dormitories which house visiting experimenters and attendees of the Management Education Center programs. The Rocket Club, WEMA activities, and a conference room are located in Building F-3. Building F-2 contains the telephone switchboard and maintenance personnel and the Mail and File area. Located in Building F-1 are the print shop and graphic services.

6. **Post Office, Gymnasium/Auditorium, and Navy Offices** - A full-service United States Post Office, an employees' stress lab for physical fitness activities, and offices for the administrative staff of the Naval Surface Warfare Center detachment are found here.

7. **Cafeteria and Photo Lab (Building E-2)** - The cafeteria is open for breakfast and lunch during most regular working hours. The WFF Optical Section is in a wing of the same building. Many different kinds of optical support are provided to the various research projects.

8. **Airport and Control Tower** - Wallops Airport has three runways, ranging in length from 4,000 to nearly 9,000 feet. The Aeronautical Project Control Center is located in the tower building (A-1) just below the control tower. The D-1 hangar houses the WFF aircraft fleet.

9. **NOAA/NESDIS CDA Station** - Across the runway is the National Oceanic and Atmospheric Administration's National Environmental Satellite and Data Information Service (NESDIS), Command and Data Acquisition Station. This station provides an unlimited 24-hour per day flow of weather satellite-derived sensor data to the Nation and world. To support this operation, nine antenna systems (ranging in size from 24- to 85-feet in diameter) and associated equipment to track, monitor, and command nine weather satellites are used 24 hours per day. The facility is divided into two separate ground stations — Polar and Geostationary. The Polar-Orbiting Environmental Satellites provide operational coverage of the entire Earth four times per day. The Geostationary Operational Environmental Satellites (GOES) observe the Eastern and Western United States and the adjacent ocean areas from their vantage points 22,300 miles over the Equator, as well as having coverage zones which extend well into the Southern Hemisphere.

10. **NASA Wallops Visitor Center (VC)** - The VC houses a collection of spacecraft and flight articles, as well as exhibits about the history of manned flight, Wallops' research activities and other NASA research projects, with an emphasis on Wallops. Special movies and video presentations can also be viewed.

11. **"E" Buildings** - There are five three-story white "E" buildings which house the sounding rocket and balloon engineering and technical personnel as well as administrative personnel (procurement, financial management) and the technical library. The NASA Management Education Center, which is used by all the NASA Centers, is located in E-104.

12. **International Flagpole Array** - The flags of visiting foreign nationals are displayed at the Wallops International Court. A sizeable portion of Wallops' effort is devoted to NASA's program of international cooperation in space research.

13. **Building F-160** - The Health Unit, Personnel and Security Offices, and the Chemistry and Calibration Labs are located here.

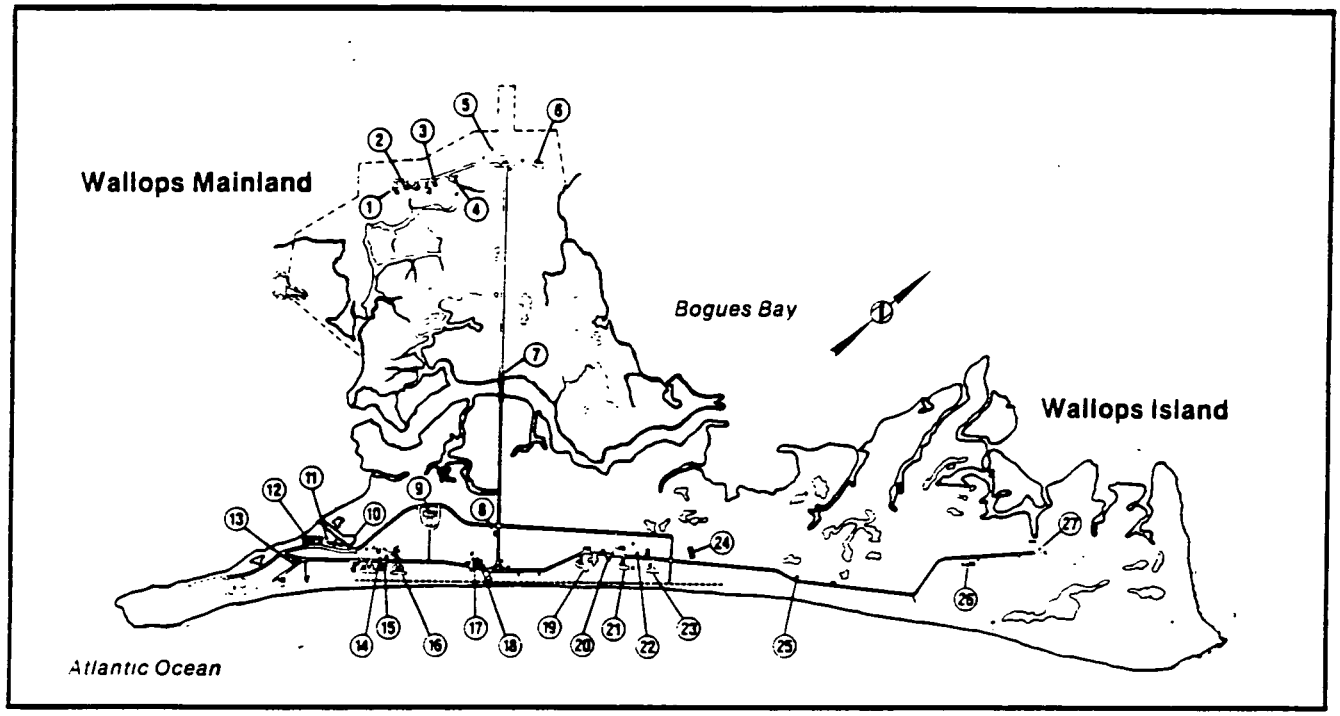
14. **Building N-159** - This large hangar houses the Wallops Range Control Center (RCC) as well as offices for range operations personnel. All rocket launchings and tracking and data acquisition operations are controlled from here. In addition, visiting aircraft conducting aeronautical research programs and visiting research teams are housed here.

15. **Building N-161** - In this main computer complex building, scientific data received from the sounding rocket, balloon, and aeronautical projects are processed to a useable form for the scientists.

16. **Building N-162** - The Wallops main Telemetry Command and Receiving Station and the Wallops Orbital Tracking Station are located here. The various antennas in this area are used to receive data from the scientific payloads launched by rockets, balloons, and research aircraft, to send commands to perform various functions, as well as to receive data from satellites. A communications receiving station and range timing and programming system also are located in this building.

17. **Navy Housing Center** - The Bachelor Officers Quarters (BOQ) building contains a total of 16 efficiency units for senior and junior officers. The Bachelor Enlisted Quarters (BEQ) dormitory has two wings, each with two stories, with an attached dining facility. It can house a maximum of 160 personnel. The family housing units provide quarters for both officers and enlisted personnel with families. Four are two-bedroom homes, and twenty-four are three-bedroom homes.

Buildings N-161 and N-162



Wallops Mainland and Island Launching Site Legend

1. **Atmospheric Sciences Research Facility (ASRF)** - The ASRF consists of instrumentation to study characteristics of the atmosphere. Two major systems are the large, powerful, ultrasensitive, research radars — the UHF and the S-Band (SPANDAR). Both radars have a 60-foot diameter antenna. Both can transmit a peak power of up to five megawatts (5,000,000 watts). SPANDAR — originally designed to track objects as far away as a quarter million miles from Earth — is sensitive enough to detect a raindrop (or an insect) 1/10 inch in diameter, seven miles away. The facility also houses several lightning detection and ranging systems. One system shows the location of almost every lightning flash that strikes the ground anywhere in the eastern one-third of the United States as they occur. Another system detects and locates all lightning within 100 miles, both cloud-to-ground and cloud-to-cloud, as well as intracloud flashes. Typical programs include the NASA Storm Hazards turbulence on airplanes; the Radio Attenuation Program, which studies the effects of rain cells on satellite communications links; and the Rocket Thunderstorm Series, which investigates the influence of electrical storms on the ionosphere.

2. **Navy Radio Transmitter Facility** - This facility contains radio transmitting equipment used to support voice and data link communications with Navy aircraft and ships.

3. **Atmospheric Physics Measurement Laboratory** - Containing photometers for determining the total amount of ozone in the atmosphere, it has the flexibility to support simultaneous experiments involving any number of instrument systems. Because of its location, it can support studies of the Earth's stratosphere and troposphere in disciplines as diverse as air pollution, synoptic weather forecasting and upper atmospheric physics.

4. **FPQ-6 Radar** - A long-range, high-precision tracking radar, it has a range capability of 32,000 miles, a measuring range with an accuracy of plus-or-minus five yards, and range-rate to an accuracy of .1 yard per second. Its peak transmitting power is three megawatts (3,000,000 watts). The antenna (parabolic reflector) is 29 feet in diameter.

5. **NSWC Operations Support Building** - The Navy's engineering staff, both permanent and transient, who support operations on the Island, are located here.

6. **WFF Radio Transmitter Building** - This building contains the radio communications transmitting equipment, both short and long-range, used to support Wallops Island activities. It also contains the radio transmitters used either to control rocket flights or destroy the rockets when necessary.

7. **Causeway and Bridge** - Almost two miles long, the Causeway was completed in 1960 at a cost of about $1.5 million. The bridge is 40 feet above mean high tide to allow clearance for water traffic on the Inland Waterway.

8. **Special Projects Building and Camera Site** - The dome on top of the building houses a tracking camera used during rocket launches. Visiting scientists and technicians also use this building as lab space for their projects being conducted on Wallops Island.

9. **Island Radar Site** - Located here are several radar systems used for tracking experiments. They have less power and range than the "big-dish radars" seen on the Mainland. They have a wider beam width and are used for "early acquisition" and range safety purposes, in addition to obtaining trajectory data.

10. **Old Dock Area** - Prior to 1960, all equipment and personnel had to be transported to the Island via boats to a dock located in this area.

11. **Liquid Propellant Storage Area** - Propellant (hydrogen peroxide) is stored here for the attitude control systems of the second and third stages of the Scout vehicle.

12. **Lagoon Sewage System** - This treatment plant (lagoon and holding pond) is part of the Island sewage treatment system. The system was installed and is operated in accordance with EPA and Virginia State requirements.

13. **NSWC Land-Based Test Site (LBTS)** - The Naval Surface Warfare Center LBTS is used to conduct research, development, test and engineering of shipboard combat systems prior to production and installation on Navy ships. Additionally, Battle Force System Engineering experiments are controlled from this facility.

14. **Assembly Shop No. 1** - All of the sounding rockets, such as the Nike, Taurus, Orion, Terrier-Malemute, and Black Brant IX and X are assembled, checked out, and prepared for launch at this location.

15. **150-Foot Meteorological Tower** - This steel tower has intruments every 50 feet for measuring low-altitude winds. Knowledge of wind direction and velocity is necessary to correct launcher angles and thus maintain proper flight paths for research vehicles. The tower occasionally is used for mounting experimental meteorological sensors or similar scientific apparatus.

16. **Launch Area No. 2 and Blockhouse No. 2** - Several types of launchers are located in this area because many types of vehicles carrying scientific experiments are launched from here. Launch Area No. 2 was the original launch site on Wallops Island. The first vehicle was fired here July 4, 1945. Since that date, thousands of experimental vehicles have been launched from this area.

17. **Launch Support Shop and Storage Area** - Located here are small shops which provide support for the launch operations and storage for miscellaneous non-hazardous material.

18. **Scout Project Office** - This was the first permanent structure erected on the Island and served as the NACA Headquarters Building. It is now used as office space for Scout support personnel. The four-stage, solid-fuel Scout vehicle has orbited 21 satellites from Wallops Island.

19. **Launch Area No. 3** - The Mark II Scout launcher is located here. It employs a horizontal type launcher which allows the vehicle to be prepared and held in the horizontal position until a short time before launch. At the proper time, the shelter building, which is mounted on steel tracks, is rolled away and the vehicle elevated to launch position. The Scout is 72 feet tall, weighs about 23 tons, and develops an average thrust of 115,000 pounds at lift-off. It is the largest vehicle currently launched at Wallops and is capable of performing a variety of missions, including the launching of satellites, space probes, and atmospheric re-entry tests. It can place a 350-pound satellite into an orbit more than 400 miles above the Earth, or loft an 80-pound scientific probe to an altitude of about 20,000 miles.

Wallops Island Launch Facilities

Near the launcher is the Scout Assembly Shop, in which the various stages, components, equipment, and payloads of the Scout launch vehicle are assembled and checked out prior to being installed on the launcher. The 21 satellites that have been launched by Wallops to date have been launched from this area.

20. **Blockhouse No. 3** - This concrete dome-shaped building north of the pad is the blockhouse from which operations on Pads 3, 4, and 5 are controlled. The walls of this building are eight feet thick reinforced concrete.

21. **Launch Area No. 4** - This area is used for special projects.

22. **315-Foot Meteorological Tower** - This steel tower also has intruments every 50 feet for measuring low-altitude winds. Information on the wind direction and its velocity is necessary to set the correct launcher angles which will maintain proper flight paths for the research vehicles. The tower is used also for mounting experimental sensors to obtain meteorological data.

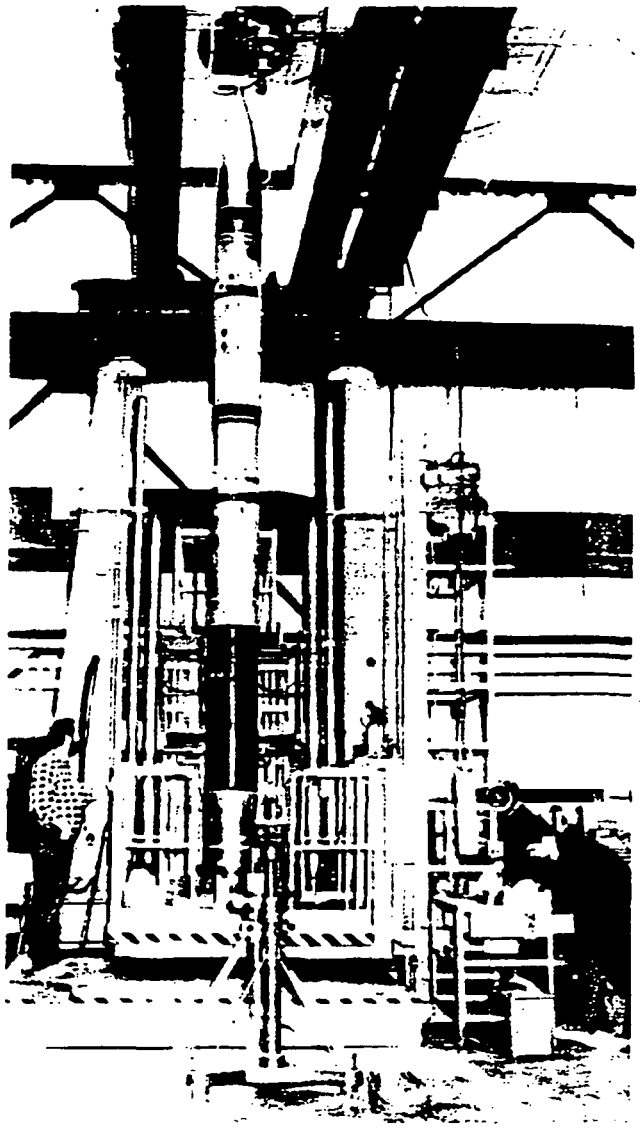
23. **Launch Area No. 5** - The Vandal target missile is launched from here. It is used as a target missile for off-shore Navy surface warship defense system tests. Vandal is a two-stage supersonic "target" about 22 feet long and 30 inches in diameter.

24. ***AEGIS* Facility** - The AEGIS Combat Systems Center (ACSC) is located here. The AEGIS system is the most modern combat system in the fleet. It consists of phased-array radars and the most integrated automatic system in use. The ACSC will be used by the Navy to engineer improvements to the existing system, to insure existing systems operate properly, and to train officers and enlisted men on the system in a realistic environment.

25. **Payload Checkout and Assembly Area** - These two buildings are used for rocket payload checkout and assembly. One is used for inert payloads and the other for "hot" payloads (payloads attached to a solid fuel rocket motor).

26. **Dynamic Balance Facility** - This structure houses equipment for vertical and horizontal spin testing and balancing of rocket motors and payloads. This operation is somewhat similar to balancing the wheels on your automobile, but far more complicated.

27. **Old Coast Guard Station** - Although no longer used by the Coast Guard, this building is used occasionally in connection with some of the experiments conducted at Wallops.



Black Brant payload ready for spin testing

NASA GSFC/WFF 1988

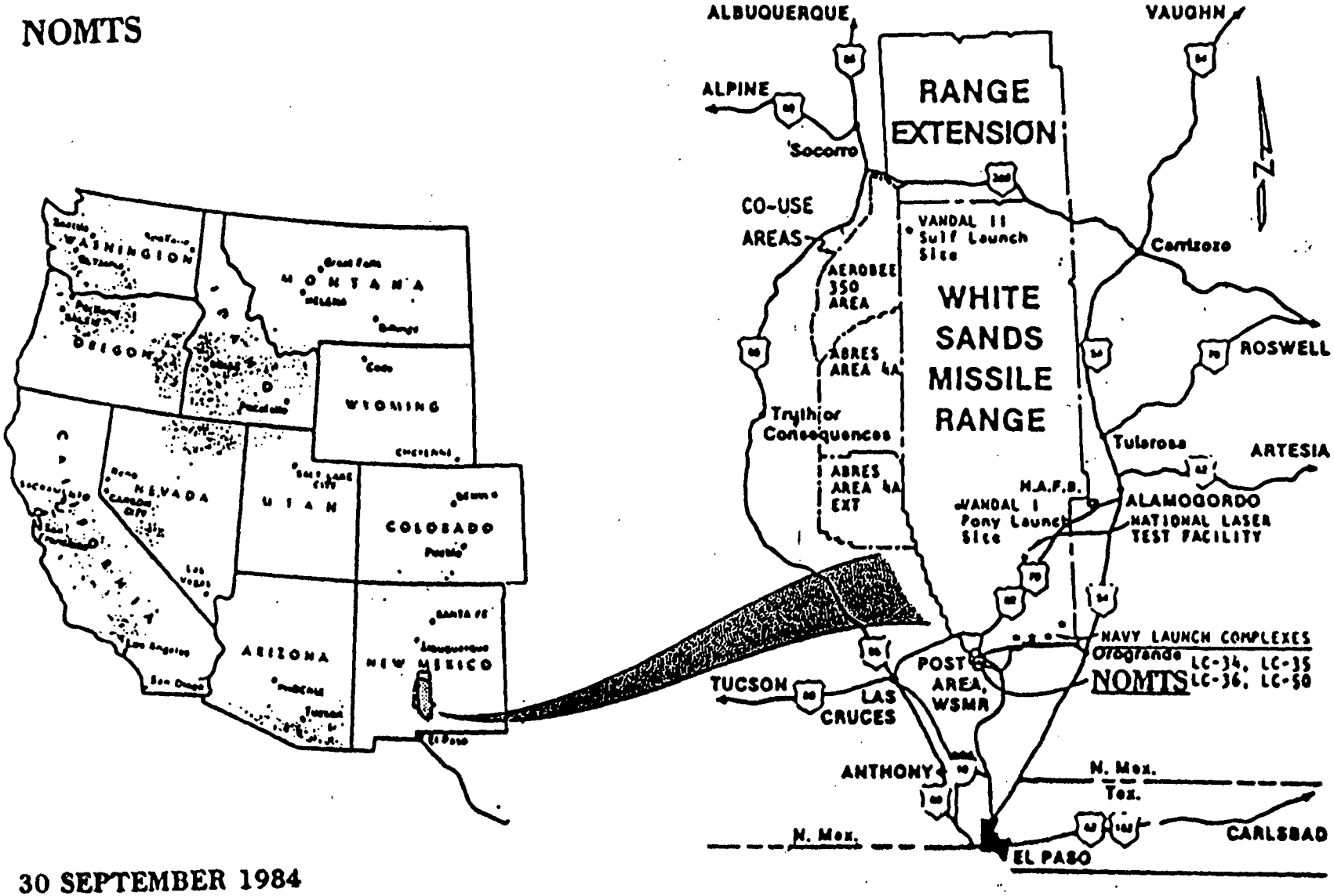
NAVAL ORDNANCE MISSILE TEST STATION

TENANT AT

WHITE SANDS MISSILE RANGE

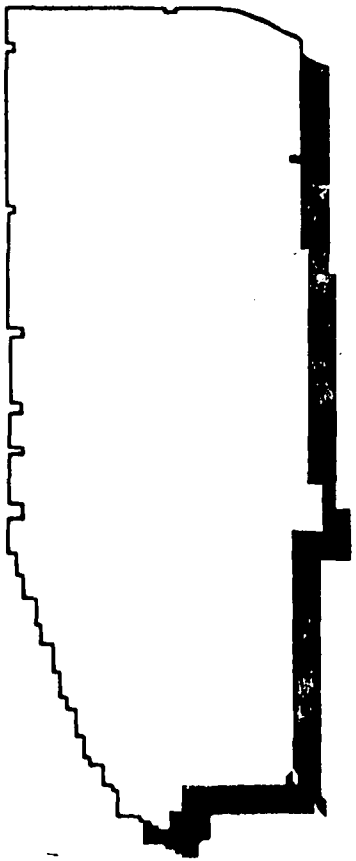
CDR Kent Watterson
Test Officer
505-678-6121
Tom Gonzales
Research Rocket Director
505-678-5502

NOMTS



30 SEPTEMBER 1984

ABOUT WHITE SANDS MISSILE RANGE



- TRI-SERVICE RANGE (NAVY, ARMY, AIRFORCE)
- MANAGED BY THE ARMY (BRIGADIER GENERAL RICHARD W. WHARTON)
- LARGEST U.S. OVERLAND TEST RANGE
  - APPROXIMATELY 40x100 MILES
  - ALTITUDE APPROXIMATELY 4,000 FT MSL
- PRECISION FIXED AND MOBILE INSTRUMENTATION (RADAR, TELEMETRY, PHOTOGRAPHY, GPS, ETC.)
- USUALLY GOOD WEATHER (350 DAYS OF SUNSHINE)
- HISTORICAL SIGNIFICANCE (ATOMIC BOMB, V2 ROCKET, TALOS, STANDARD MISSILE)
- SAN ANDRES WILDLIFE REFUGES
- THREATENED, ENDANGERED & CANDIDATE SPECIES (35 SPECIES LISTED)
- HISTORICAL & ARCHEOLOGICAL SITES (OVER 1000)

NAVY PROGRAMS

SURFACE/AIR MISSILES

- STANDARD MISSILE BLOCK III PSR
- STANDARD MISSILE BLOCK IIIA
- STANDARD MISSILE BLOCK IIIB
- STANDARD MISSILE BLOCK IV
- STANDARD MISSILE NAVY LEAP
- ROLLING AIRFRAME MISSILE (RAM)
- NATO SEA SPARROW MISSILE

SURFACE/SUBSURFACE

- SEALANCE
- VERTICAL LAUNCH ASROC

SURFACE GUN WEAPONS

- FUTURE GUN TECHNOLOGY
- GUNLINE

AIR/SURFACE WEAPONS

- STANDOFF LAND ATTACK MISSILE
- NAVAL AIR WEAPONS TEST
- NAVY AMRAAM

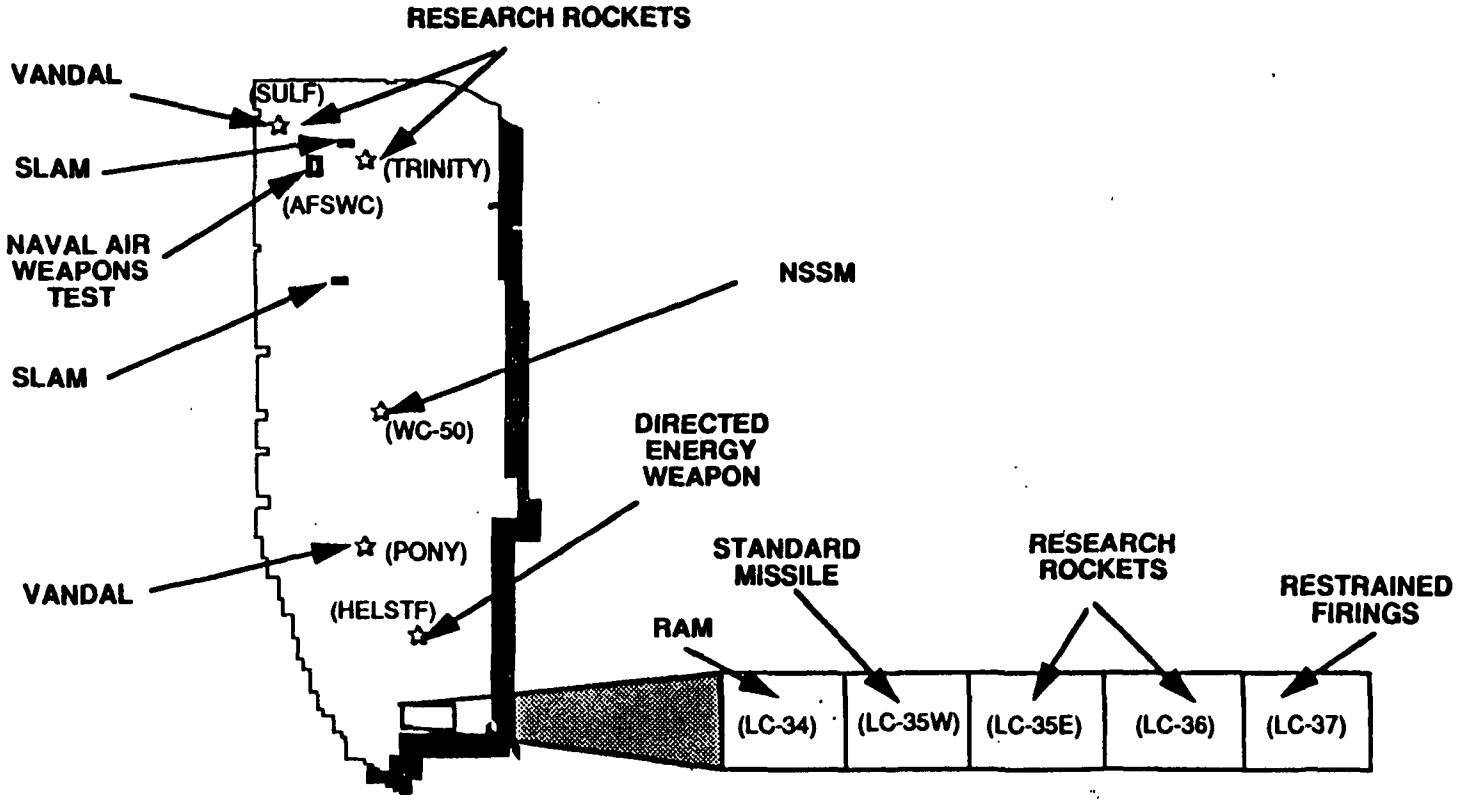
NAVY TARGETS

- VANDAL
- AQM-37C(EP)
- HIGH ALTITUDE TARGET SYSTEM
- SPECIALIZED GROUND TGTS

SPACE ROCKETS

- NASA RESEARCH ROCKETS
- LEAP 1-4
- ERINT/PATRIOT TARGET
- HEDI KITE TARGET
- THAADS TARGET
- COMMERCIAL

NOMTS TEST SITES



RESEARCH ROCKET PROGRAMS AT THE NAVAL ORDNANCE MISSILE TEST STATION

45 YEARS EXPERIENCE IN THE SOUNDING ROCKET BUSINESS, OVER 1070 LAUNCHES.

CUSTOMERS INCLUDE DEPARTMENT OF DEFENSE, NASA AND COMMERCIAL.

COMPLETE FACILITIES FOR PAYLOAD BUILD-UP AND INTEGRATION, ORDNANCE STORAGE, LAUNCH AND RECOVERY.

FULL CAPABILITY OF WHITE SANDS MISSILE RANGE FOR DATA COLLECTION.

PERFECT SAFETY AND SECURITY RECORD.

6 LAUNCHERS ARE AVAILABLE; 8 ROCKET TYPES HAVE BEEN FLOWN.

RESEARCH ROCKETS
BOOSTER CAPABILITY

BOOSTER	LAUNCH COMPLEX	LAUNCHER TYPE
BLACK BRANT	LC-35W; LC-36	TOWER (3FIN); TOWER 4 FIN, RAIL
TERRIER - BLACK BRANT	LC-35W; LC-36	TOWER (3FIN); TOWER 4 FIN, RAIL
NIKE - BLACK BRANT	LC-35W; LC-36	TOWER (3FIN); TOWER 4 FIN, RAIL
ARIES	LC-36	STOOL, ATHENA RAIL
	SULF	STOOL, STARBIRD RAIL (PROPOSED)
ORION	LC-36	RAIL
	SMR (PROPOSED)	
TARUS - ORION	LC-36	RAIL
	SMR (PROPOSED)	
NIKE - ORION	LC-36	RAIL
	SMR (PROPOSED)	

PLANNED BOOSTER CAPABILITY

SERGEANT-M57	SULF	STOOL, STARBIRD RAIL (PROPOSED)
	LC-36	STOOL, ATHENA RAIL
MIST	VARIOUS	VARIOUS

CURRENT BOOST CAPABILITIES

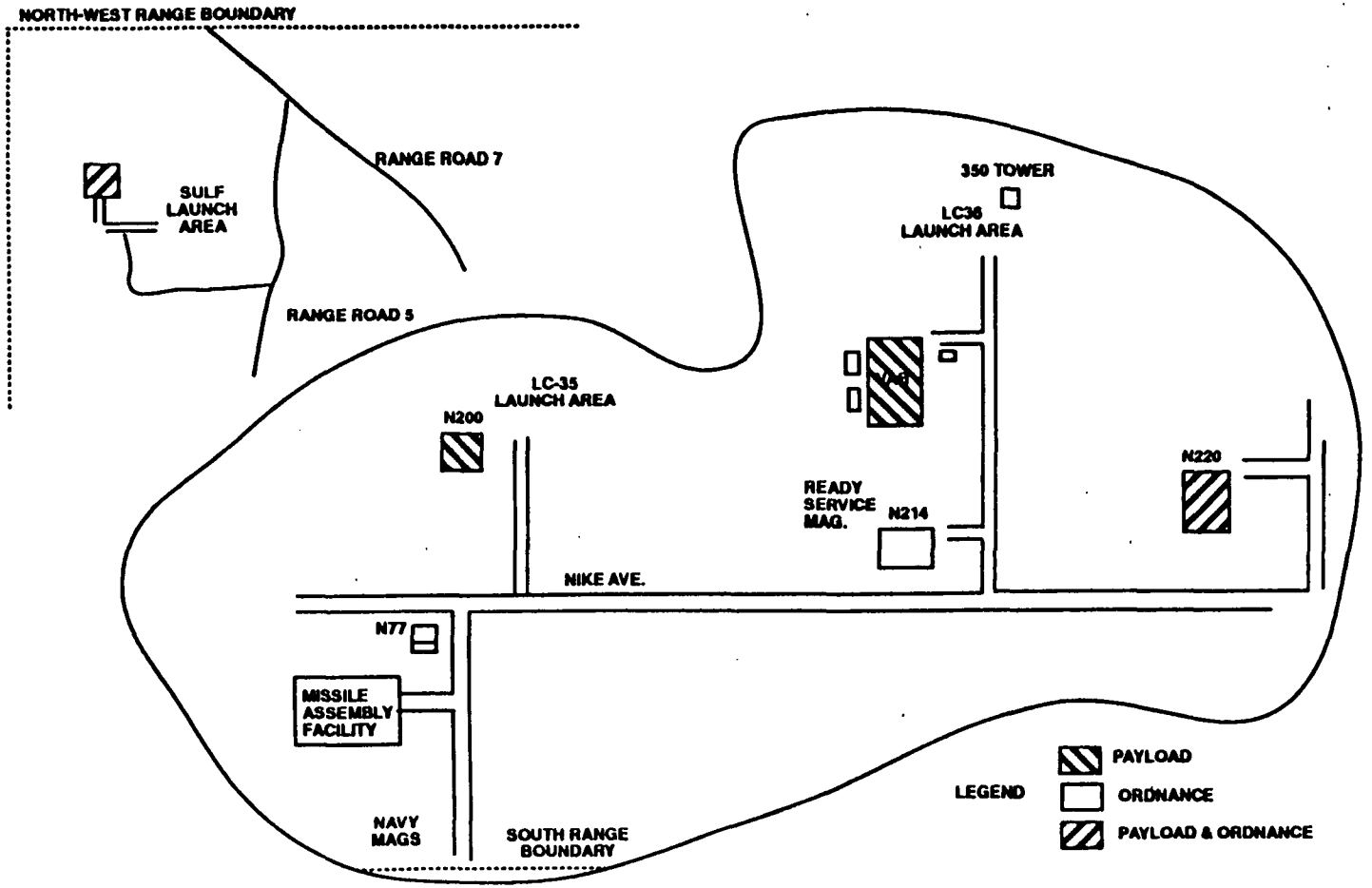
PROPULSION	ALTITUDE (MILES)	PAYLOAD (LBS)	LAUNCHERS
BLACK BRANT (BB)	95/200	920/375	3,4 FIN TOWERS 7.5K RAIL
TERRIER / BLACK BRANT (TBB)	145/235	1050/560	3,4 FIN TOWERS 7.5K RAIL
NIKE / BLACK BRANT (NBB)	125/230	1020/490	3,4 FIN TOWERS 7.5 RAIL
ARIES (MM STAGE 2)	75/360	5200/1000	STOOL (NORTH, SOUTH)
ORION	24/100	290/50	4.3K RAIL (INACTIVE)
NIKE / ORION	90/130	300/70	7.5K RAIL
TAURUS / ORION	125/215	330/80	7.5K RAIL
SERGEANT/M57	TBD	TBD	STOOL (NORTH, SOUTH)

NOTES: 1) 40K (54 FT) RAIL LAUNCHER COMPATIBLE WITH BB, TBB, NBB, AND ARIES IS BEING INSTALLED IN EARLY 1992 AT LC-36. THIS LAUNCHER WILL PROVIDE INCREASED CAPABILITY FOR PLANNED BOOSTERS.

2) RAIL LENGTHS ARE 37 FT (7.5K LAUNCHER), 140 FT (3 FIN TOWER LAUNCHER) AND 160 FT (4 FIN TOWER LAUNCHER).

3) 50K STARBIRD LAUNCHER MAY BE INSTALLED AT SULF SITE IN 1992.

RESEARCH ROCKETS ORDNANCE AND PAYLOAD ASSEMBLY AREAS



ORDNANCE AND PAYLOAD ASSEMBLY

ORDNANCE ASSEMBLY

BUILDING	DIMENSIONS	SQ. FT.	NEW	REMARKS
N-77-S	20X60	1,200	12,000	(DELETE IN 2ND QTR 92)
MAF	72X40	2,880	5,500	(ADD IN 2ND QTR 92)
N-220	29X70	2,030	4,000	
N-214	39X28	1,092	8,000	(READY IN SERVICE MAG)
SULF	28X60	1,680	11,000	
350 TOWER RUNWAY	66X15	990	4,500	(BACK UP)

PAYLOAD ASSEMBLY

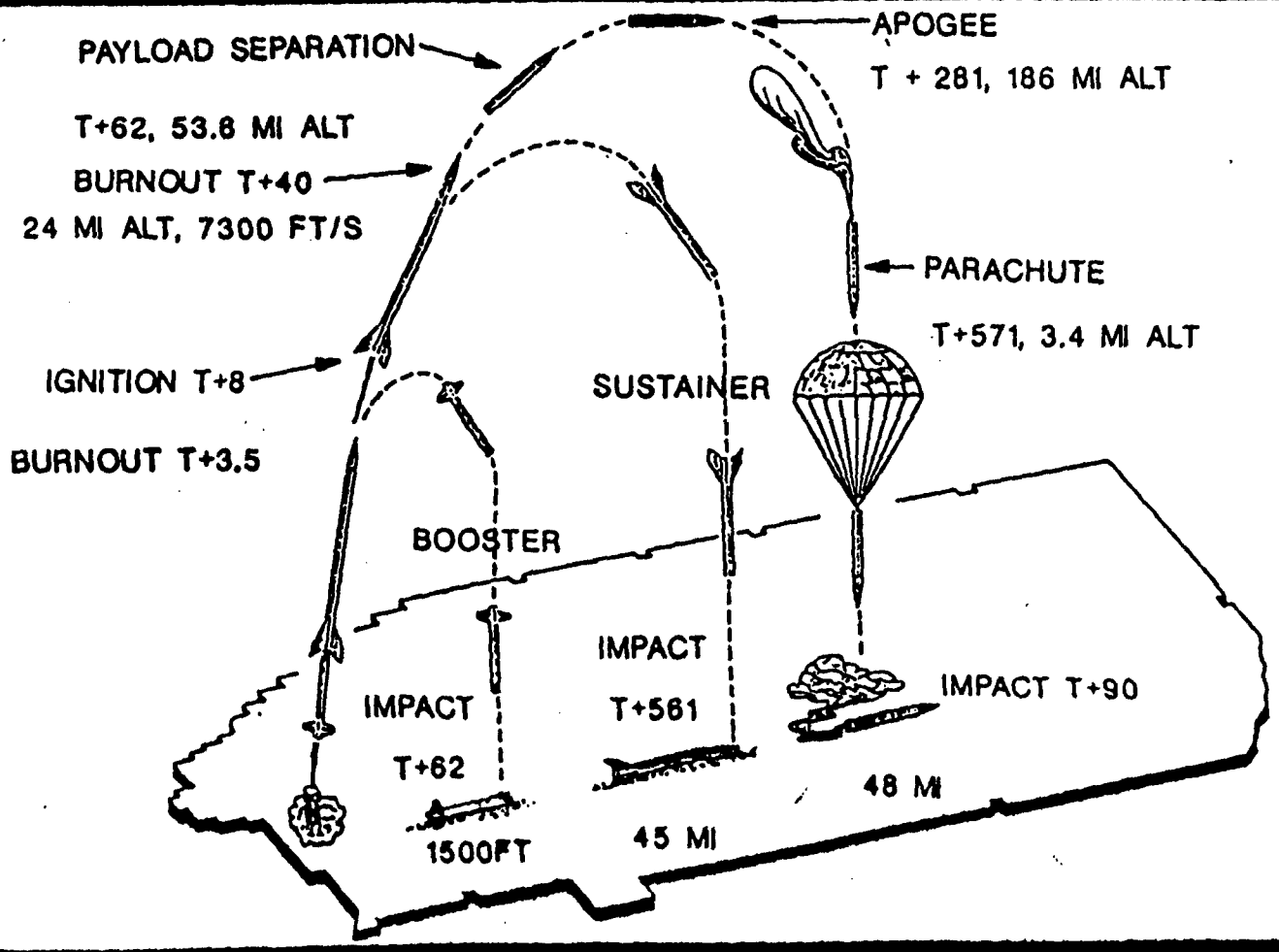
N-200 6,500 SQ. FT. (INCLUDES OFFICES, LABS, BUILDUP AREA)
ALSO CONTAINS GROUND STATION, OPTICS LAB, UPLINK STATION

VAB - HIGH BAY 60X40 - 54' HOIST HEIGHT; LOW BAY 80X40-32' HOIST HEIGHT WITH 19'Wx32'H DOOR.
ALSO CONTAINS GROUND STATION, VIBRATION, SPIN BALANCE, BENT

N-220 2030 SQ. FT.

SULF 2760 SQ. FT.

TYPICAL NIKE BLACK BRANT LAUNCH



NOMTS RESEARCH ROCKET SERVICES

RANGE SPONSOR

- REVIEW/FORWARD ALL RANGE DOCUMENTATION
- COORDINATE SERVICES/MEETINGS WITH NATIONAL RANGE
- SCHEDULE PRELAUNCH AND LAUNCH TESTS

FACILITIES AND EQUIPMENT

- SCHEDULE USE OF NOMTS FACILITIES FOR ROCKET MOTOR AND PAYLOAD ASSEMBLY, PAD INTEGRATION, PRELAUNCH TESTS, LAUNCHES
- GROUND SAFETY AND SECURITY
- ENGINEERING AND FABRICATION SERVICES
- ORDNANCE STOWAGE
- CRANE, FORKLIFTS, AND OTHER HANDLING EQUIPMENT

MISSION MANAGEMENT

- PROCURE CONSUMABLES, FACILITY MODIFICATION ITEMS, SPECIAL EQUIPMENT
- BUDGET ESTIMATES, FUNDS DISPURSEMENT AND EXPENDITURE REPORTS
- LOAD, COUNTDOWN AND LAUNCH OPERATIONS
- TECHNICAL SUPPORT
- PAO WITH WSMR

NOMTS/WSMR/ARMTE

NOMTS

- TEST SUPPORT PLANNING
- RANGE SPONSOR
- MISSION SCHEDULING
- ORDNANCE HANDLING
- TARGET AUGUMENTATION
- TEST SITE PREPARATION
- SAFETY
- SECURITY

NATIONAL RANGE

- RANGE SUPPORT PLANNING
- SC/OD DOCUMENTATION
- RANGE SCHEDULDING
- FLIGHT SAFETY
- SAFETY ENGINEERING
- DATA REDUCTION & ANALYSIS

MISSION SUPPORT

- MISSION CONTROL
- REAL TIME SYSTEMS
- INSTRUMENTATION
  - TELEMETRY
  - RADAR (BEACON CKS)
  - TRACKING CAMERAS
  - NON-TRACK CAMERAS
  - VIDEO
- COMMUNICATIONS
- FREQUENCY SURVEILLANCE
- AREA SURVEILLANCE
- ROADBLOCKS
- RECOVERY/EOD

ARMTE

- CHEMISTRY LAB
- X-RAY LAB
- DYNAMIC ENVIRONMENT LAB
  - SHOCK/VIBRATION/NOISE
  - COMBINED CLIMATIC
- MICROBIOLOGICAL
- ELECTROMAGNETIC

OTHER

- ASL - METEOROLOGY
- DMA - GEODETIC SURVEY
- DOD-AFC - FREQ. COORDINATOR
- EL-PM - MASTER PLANNING
- EL-N - ENVIRONMENTAL OFFICE
- EL-LM - TRANSPORTATION
- MICOM - CALIBRATION LAB
- MICOM - TARGETS
- ASQNC-TWS - COMMUNICATIONS
- HAFB - 6585 TEST SQUADRON

NASA FACILITIES

PAYLOAD SPIN BALANCING AND VIBRATION

REAL TIME METEOROLOGICAL LAUNCH ANALYSIS (REAL TIME AT WALLOPS)

STAR COLLIMATION AND SUN SENSOR CALIBRATION (LOCKHEED)

PSL/NMSU CONTRACTOR SUPPORT (VIA NASA OR PSL)

- TELEMETRY
- BLACK BRANT IGNITOR HOUSING FTS MODS
- ORSA ACCEPTANCE TESTING
- RANGE PRECISION ACQUISTION SYSTEM DISPLAY AT LC36

STADS CONTRACTOR SUPPORT

- LAUNCH PAD PREPARATIONS
- LAUNCH OPERATIONS

COMMERCIAL SPACE LAUNCH HISTORY

SPACE SERVICES INCORPORATED, HOUSTON, TX

- THREE LAUNCHES - MAR 89; NOV 89; MAY 90
- PURPOSE: MATERIALS DEVELOPMENT IN MICROGRAVITY
- PAYLOAD USERS: U ALABAMA (HUNTSVILLE)
- BOOSTERS: TERRIER BLACK BRANT

SPACE SERVICES DIVISION/ENGINEERING ECONOMIC RESEARCH INC, SEABROOK, MD

- *LAUNCH PLANNED FOR 13 NOV 91*
- PURPOSE: MATERIALS DEVELOPMENT IN MICROGRAVITY
- PAYLOAD USERS: U ALABAMA (HUNTSVILLE)
- BOOSTERS: TERRIER BLACK BRANT

SPACE DATA DIVISION/ORBITAL SCIENCES CORPORATION, CHANDLER, AZ

- FOUR LAUNCHES OF LIGHTWEIGHT EXO-ATMOSPHERIC PROJECTILE (LEAP) IN FY 92
- PURPOSE: LEAP INTERCEPT OF THRUSTING TARGET
- PAYLOAD USER: SDIO

COMMERCIAL SPACE LAUNCH ACT LAUNCH UNIQUE REQUIREMENTS

FOR USE OF NOMTS FACILITIES/SERVICES

- DOT LICENSE
- MEMORANDUM OF AGREEMENT WITH NAVY
- INSURANCE IN PLACE BEFORE WORK BEGINS (LEVELS PRESCRIBED IN NAVY MOA)

FOR USE OF OTHER WSMR FACILITIES/SERVICES

- NATIONAL RANGE VIA OPERATIONS REQUIREMENT DOCUMENT THRU NOMTS
- ARMTE VIA LETTER THRU NOMTS
- NASA VIA MOA/NEGOTIATION DIRECT WITH NASA

CUSTOMER RESPONSIBILITIES

DETAILS ARE DISCUSSED AT KICKOFF MEETING

- OBTAIN DOT LICENSE, NAVY MOA AND INSURANCE
- ESTABLISH AGREEMENTS FOR NASA FACILITIES/SERVICES
- PROVIDE FUNDING
- PREPARE NOMTS AND RANGE DOCUMENTATION
- DEFINE ALL OPERATIONS HAZARDS AND HERO SUSCEPTIBILITY DATA
- PROVIDE CERTIFIED ORDNANCE HANDLING EQUIPMENT (NWS EARLE, NJ), ORDNANCE HANDLERS, AND SSOPs
- PROVIDE RANGE TECHNICAL DATA FOR FLIGHT TRAJECTORIES, FAILURE MODES AND EFFECTS, IMPACT FOOTPRINTS/PROBALILITIES, FTS QUALIFICATION AND OTHER DATA
- IDENTIFY ENVIRONMENTAL HAZARDS THROUGH FORMAL DOCUMENT WITH RANGE AND STATE (IF NEEDED)
- DEFINE ASSEMBLY/PAD SUPPORT INTERFACE REQUIREMENTS (POWER, CLEAN ROOM, HVAC, ETC) IN FLIGHT REQUIREMENTS PLAN
- IDENTIFY PROPRIETARY INFORMATION
- OBTAIN RADIO FREQUENCY ASSIGNMENTS (RFAs)

POTENTIAL LONG LEAD TIMES

ENVIRONMENTAL APPROVAL

MASTER PLANNING BOARD APPROVAL

FLIGHT TERMINATION SYSTEM QUALIFICATION

FLIGHT SAFETY DATA. EXOTIC PERFORMANCE ENVELOPES MAY REQUIRE DEVELOPMENT OF SPECIAL FLIGHT SAFETY ANALYSIS SOFTWARE/HARDWARE TOOLS

PROGRAM INTRODUCTION/STATEMENT OF CAPABILITY DOCUMENTS APPROVAL

TRANSMITTER TYPE ACCEPTANCE/RFA PROCESS

DOT LICENSE, MOA, INSURANCE PROCESS

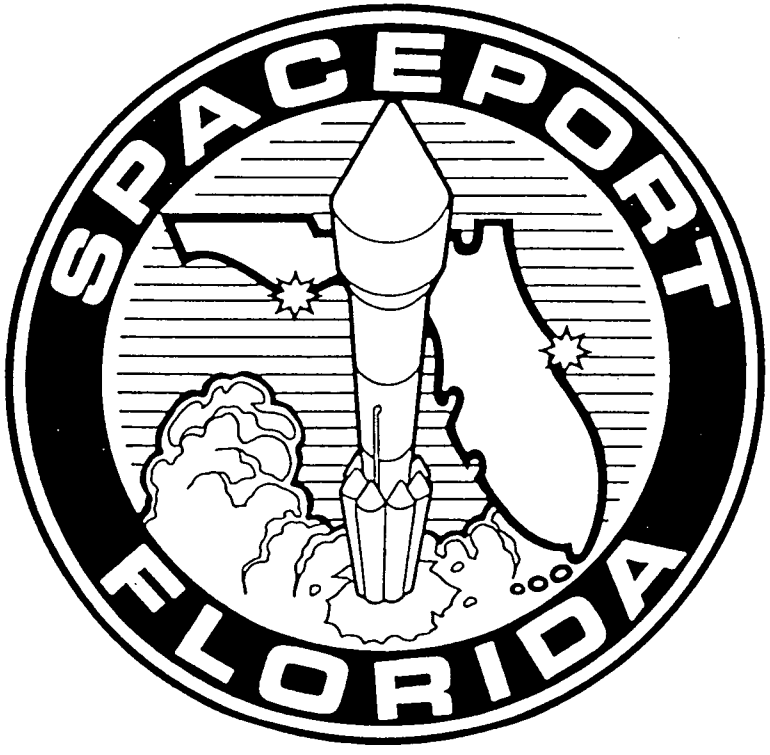
OMIT

Stephen Morgan

Virginia Center for Innovative Technology (CIT)

Presentation not Available

SPACEPORT FLORIDA AUTHORITY



SPACEPORT FLORIDA
ORGANIZATION

- ESTABLISHED BY THE STATE LEGISLATURE IN 1989.
- CREATED AS A PUBLIC CORPORATION AND SUBDIVISION OF STATE GOVERNMENT.
- EXECUTIVE DIRECTOR REPORTS TO NINE-MEMBER BOARD OF SUPERVISORS.
- SMALL, MULTI-DISCIPLINARY STAFF (9 PERSONS).
- OFFICES LOCATED IN VICINITY OF KENNEDY SPACE CENTER AND CAPE CANAVERAL AIR FORCE STATION.

SPACEPORT FLORIDA

OBJECTIVE

- TO BRING TO FLORIDA ADDITIONAL COMPONENTS OF THE NATION'S COMMERCIAL, CIVIL, AND MILITARY SPACE PROGRAMS

  * SUPPORTING AND AUGMENTING THE NATIONAL SPACE CAPABILITY.

  * RETAINING AND STRENGTHENING THE U.S. LAUNCH INDUSTRY.

  * DEVELOPING SPACE-RELATED RESEARCH AND MANUFACTURING CAPABILITIES.

  * INCREASING UNIVERSITY PARTICIPATION IN SPACE-RELATED RESEARCH.

SPACEPORT FLORIDA
CURRENT INITIATIVES

- COMMERCIAL LAUNCH INFRASTRUCTURE AND SYSTEMS MODERNIZATION PROGRAM
  - * ADVANCED LAUNCH CONTROL CENTER
- CAPE SAN BLAS LAUNCH PROGRAM
  - * UNIVERSITY CURRICULUM DEVELOPMENT
- SPACEPORT FLORIDA LABORATORIES
- NATIONAL LAUNCH DEVELOPMENT CENTER
- BOND FINANCE PROJECTS
- TELECOMMUNICATIONS NASA CCDS

SPACEPORT FLORIDA

SPACE RESEARCH EXPERIMENT PROGRAM

OBJECTIVES

1. PROVIDE UNIVERSITY RESEARCHERS WITH RAPID ACCESS TO SPACE.

2. PROMOTE RESEARCH ON ENVIRONMENTAL MONITORING LEADING TO A BETTER UNDERSTANDING OF GLOBAL CHANGE.

3. ASSIST IN THE ESTABLISHMENT OF FLORIDA AS A LEADER IN SPACE-RELATED RESEARCH WHICH WILL LEAD TO A LARGER SHARE OF COMMERCIAL SPACE ENTERPRISE.

4. STIMULATE STUDENT INTEREST IN SPACE TO HELP ESTABLISH A WORK FORCE ATTUNED TO 21ST CENTURY TECHNOLGY.

SPACEPORT FLORIDA

SPACE RESEARCH EXPERIMENT PROGRAM

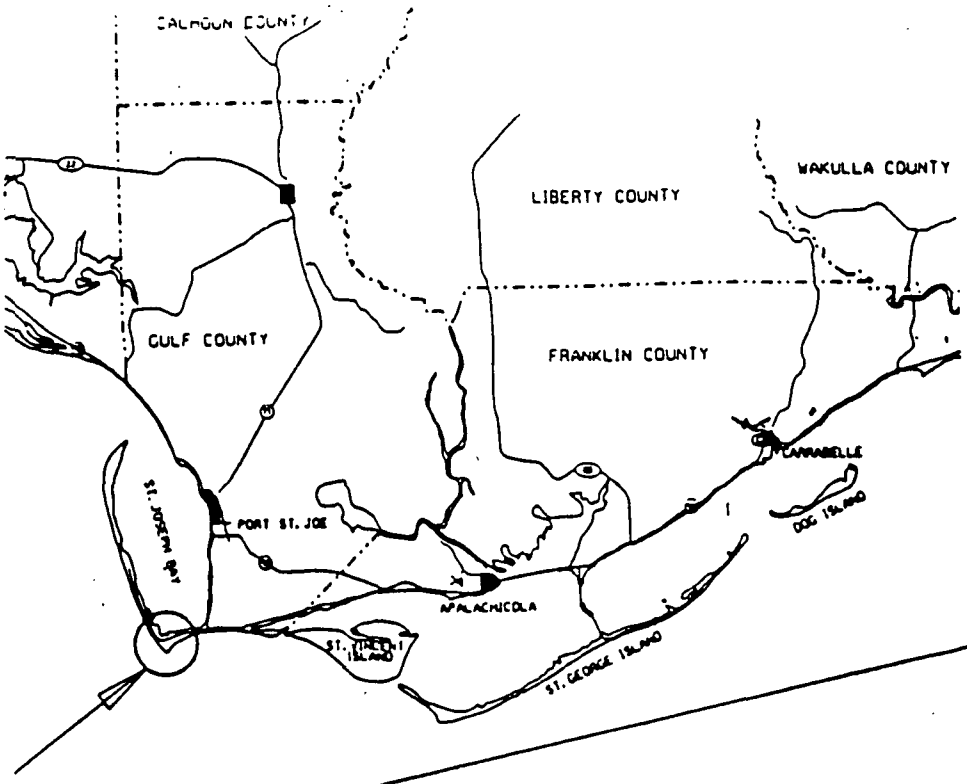
PROGRAM ASSETS

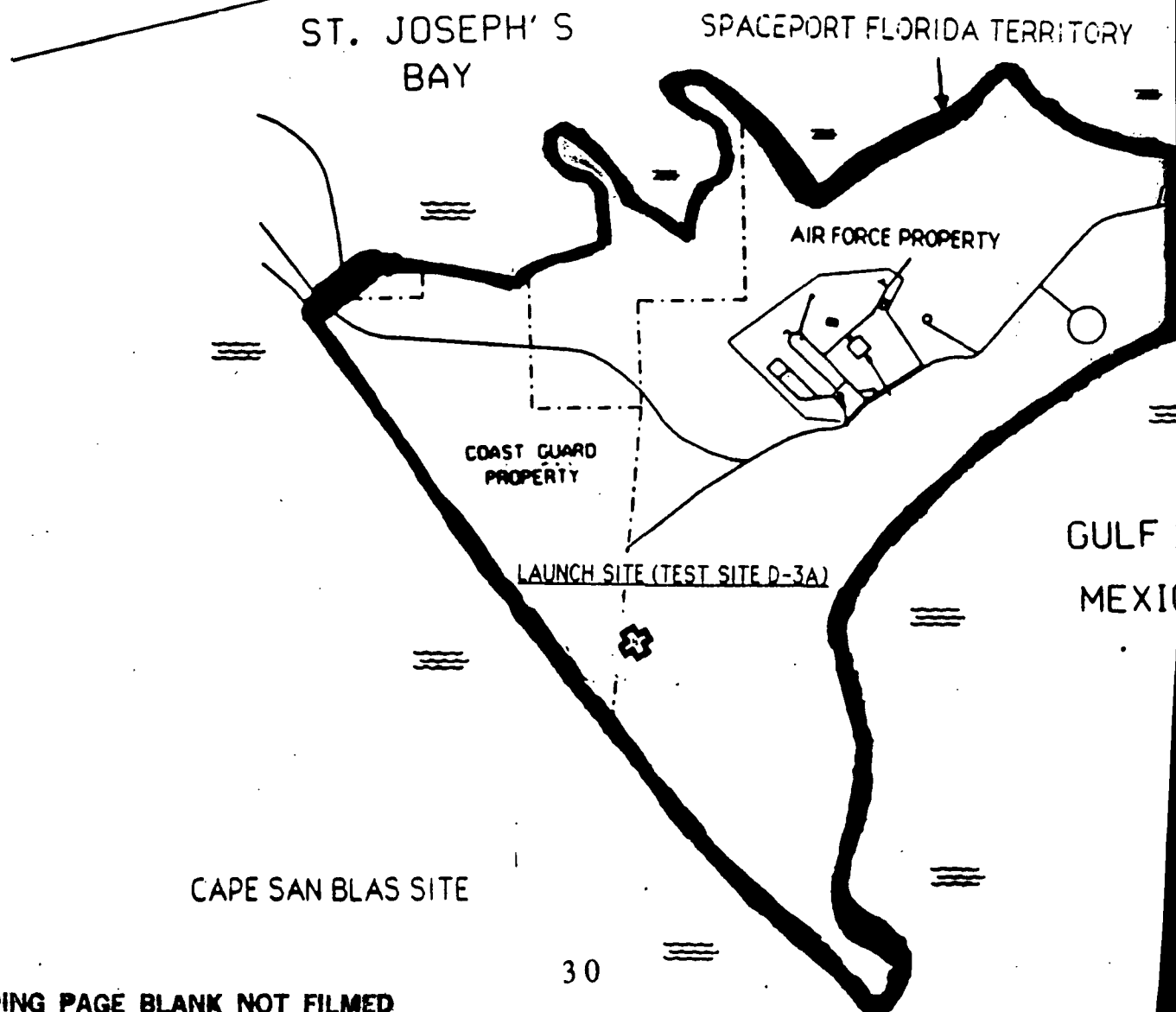
- CAPE SAN BLAS FACILITY
  - LAUNCH CONTROL VAN AND LAUNCHER
  - VIPER III/SUPER LOKI ROCKETS
  - GROUND TRACKING AND TELEMETRY (USAF)
  - PAYLOAD RECOVERY CAPABILITY
- SPACEPORT FLORIDA LABORATORIES
  - PAYLOAD FLIGHT QUALIFICATION TEST FACILITY
  - PAYLOAD DEVELOPMENT FACILITY
- INCUBATOR FACILITY
- SPACEHAB LOCKERS RESERVATION

SPACEPORT FLORIDA

CAPE SAN BLAS LAUNCH PROGRAM

- SUB-ORBITAL LAUNCH FACILITY IN GULF COUNTY FOR UNIVERSITY-DEVELOPED AND SMALL COMMERCIAL PAYLOADS.
- FACILITY ACTIVATION (INCLUDING LAUNCH VEHICLES AND SUPPORT EQUIPMENT) UNDER CONTRACT TO ORBITAL SCIENCES CORPORATION.
- FIRST SAN BLAS LAUNCH SCHEDULED IN DEC. 1991 *F.S.U. METEOROLOGICAL PAYLOAD
- ANTICIPATED SHORT TERM LAUNCH RATE OF SIX PER YEAR.
- SOLAR ECLIPSE LAUNCH ON JULY 11 FOR F.I.T. AT AT SANTIAGO IXCUINTLA, MEXICO





CAPE SAN BLAS SITE

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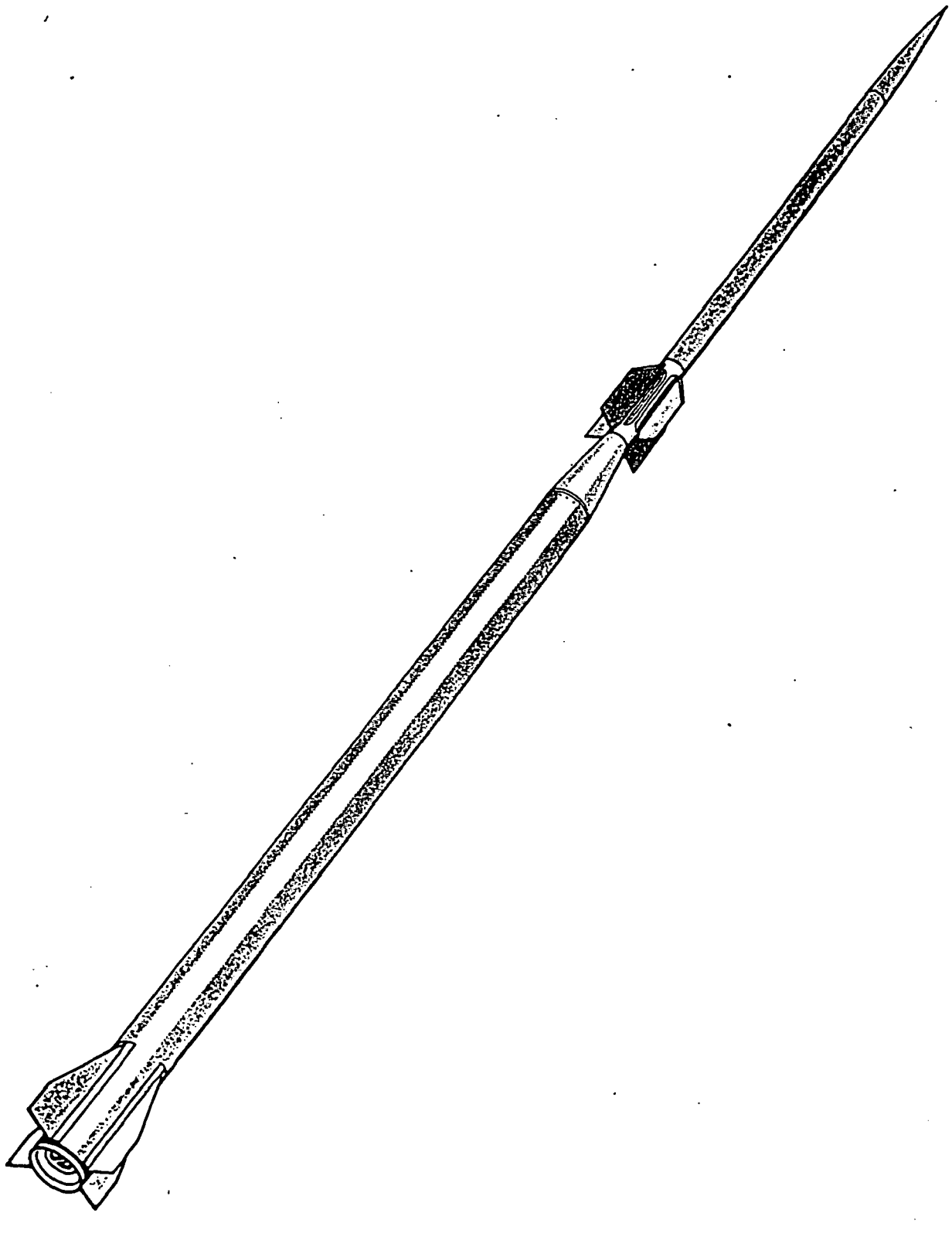


FIGURE 5.1 SUPER LOKI INSTRUMENT DART VEHICLE

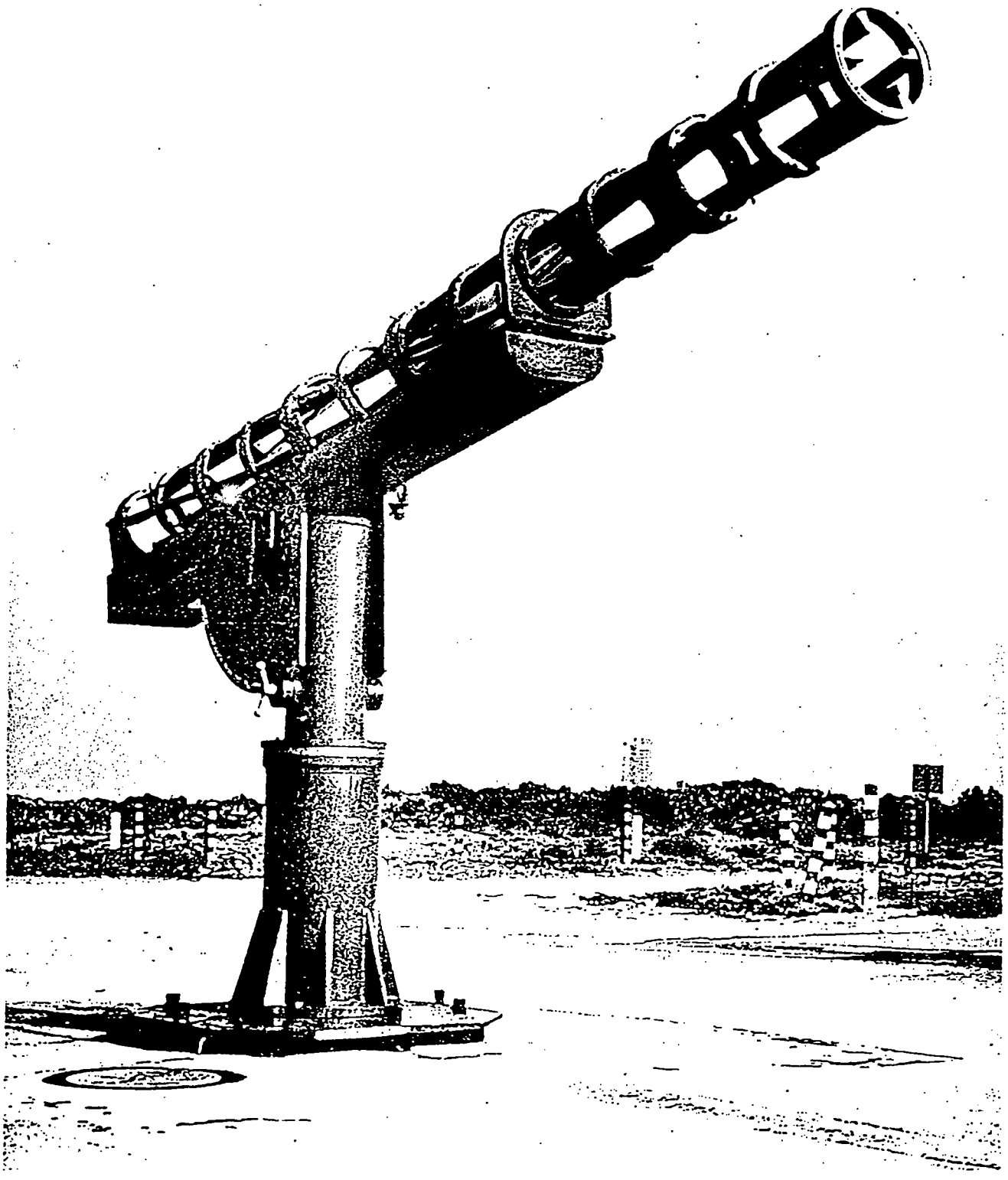


FIGURE 6.2 SUPER LOKI LAUNCHER

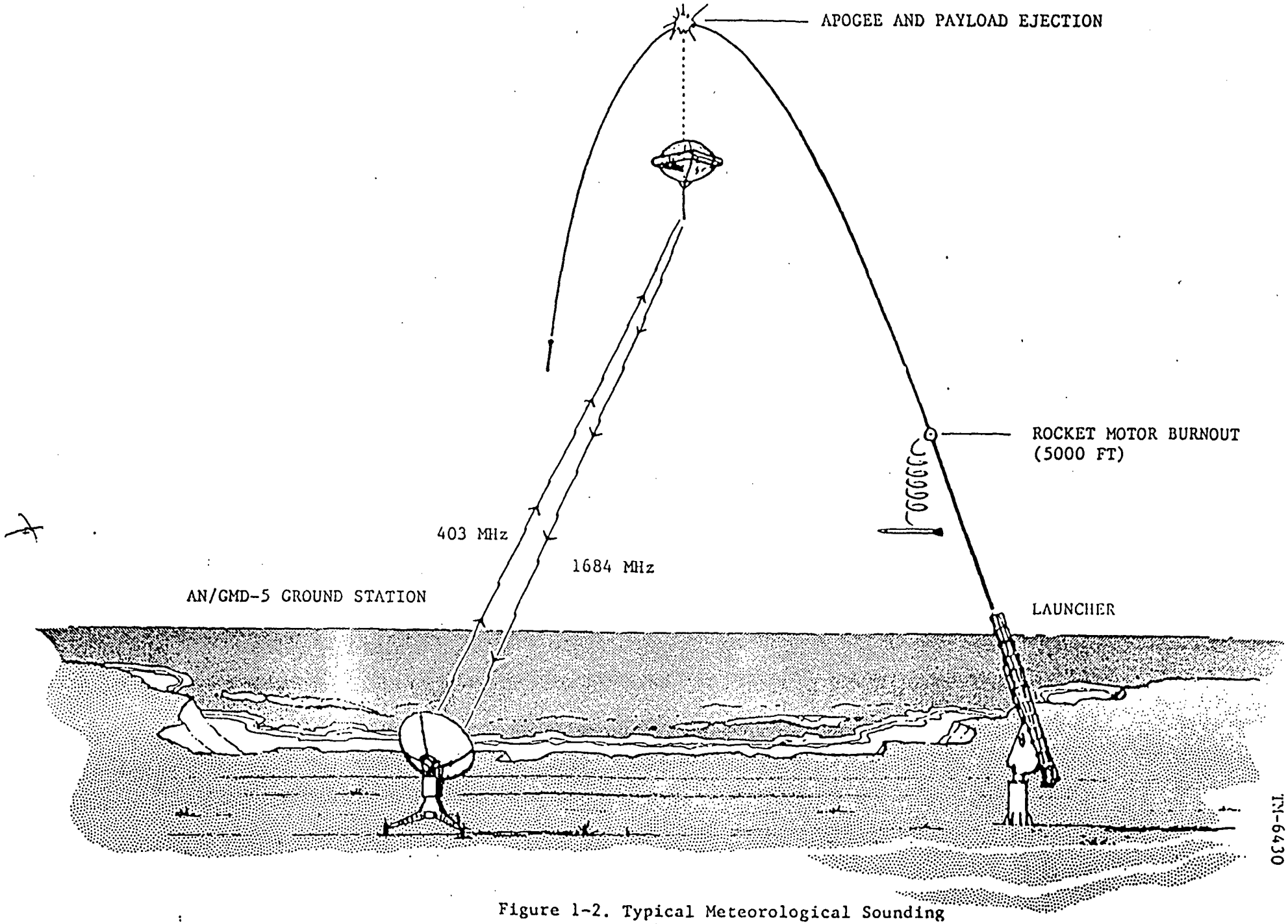


Figure 1-2. Typical Meteorological Sounding Rocket System

SPACEPORT FLORIDA

SPACE RESEARCH EXPERIMENT PROGRAM

LAUNCH VEHICLE CHARACTERISTICS

SOUNDING ROCKET PERFORMANCE CHARACTERISTICS

[As provided by the manufacturer, Space Data Division (SDD) of the Orbital Sciences Corporation (OSC).

Dart Configuration

TYPE	DIA.	WT.	Payload LN.	Payload DIA.	Payload WT.
A	2 1/8	16.5	31 in.	2 in.	8-11 lb.
B	1 7/16	10.0	25 in.	1 5/16	5-6 lb.
C	1 5/8	13.5	22 in.	1 1/2	6-8 lb.

	Super Loki				Viper III A			
	Booster Burnout		Dart Apogee		Booster Burnout		Dart Apogee	
TYPE	Ft.	Mach	Kft	Sec	Ft.	Mach	Kft	Sec
A	4300	4.82	200	110	5750	5.27	260	125
B	4800	5.38	240	120	6300	5.81	300	135
C	4550	5.10	310	145	5950	5.39	340	150

SPACEPORT FLORIDA

SPACE RESEARCH EXPERIMENT PROGRAM

LAUNCH MANIFEST

#	LAUNCH DATE	LOCATION	UNIVERSITY	PAYLOAD	MISSION	COMMENTARY
1	10 JULY 91	Santiago Mexico	-	SONDE	Systems Test of Ground Equipment	Successful Launch Demo
2	11 JULY 91	Santiago Mexico	F.I.T.	SECC-1	Solar Eclipse Extended Corona Determine Composition of Solar Dust	No Data Received After Launch
3	NOV-DEC 91	Cape San Blas Florida	F.S.U.	Weather Sonde	1. Determine Wind and Temp Data at Extreme Altitudes 2. Systems Test of San Blas Facility	EA Submitted To Eglin AFB, Awaiting Launch Date Assignment
4	JAN 92	Cape San Blas Florida	F.S.U.	Trace Gas Ozone Detector	Vertical Atmospheric Profiles Global Warming Data	Can Be Correlated With Satellite Data
5	APRIL 92	Cape San Blas Florida	F.S.U.	Trace Gas Ozone Detector	Vertical Atmospheric Profiles Global Warming Data	Can Be Correlated With Satellite Data
6	JULY 92	Cape San Blas Florida	F.S.U.	Trace Gas Ozone Detector	Vertical Atmospheric Profiles Global Warming Data	Can Be Correlated With Satellite Data

SPACEPORT FLORIDA

SPACE RESEARCH EXPERIMENT PROGRAM

POTENTIAL AREAS OF INVESTIGATION

- SCIENCE
  - METEOROLOGY
    - STRATOSPHERIC TRACE GAS MEASUREMENT (OZONE)
    - UPPER ATMOSPHERIC PROFILES
  - ASTRONOMY
    - SOLAR PHENOMENA
    - STAR SCINTILLATION
  - PHYSICS
    - MICROGRAVITY EFFECTS
    - COMMUNICATION SPECTRUM STUDIES
- ENGINEERING
    - SENSOR DEVELOPMENT
    - SATELLITE SYSTEM QUALIFICATION
    - COMMUNICATION SYSTEM TESTING

SPACEPORT FLORIDA

SPACEPORT FLORIDA LABORATORIES

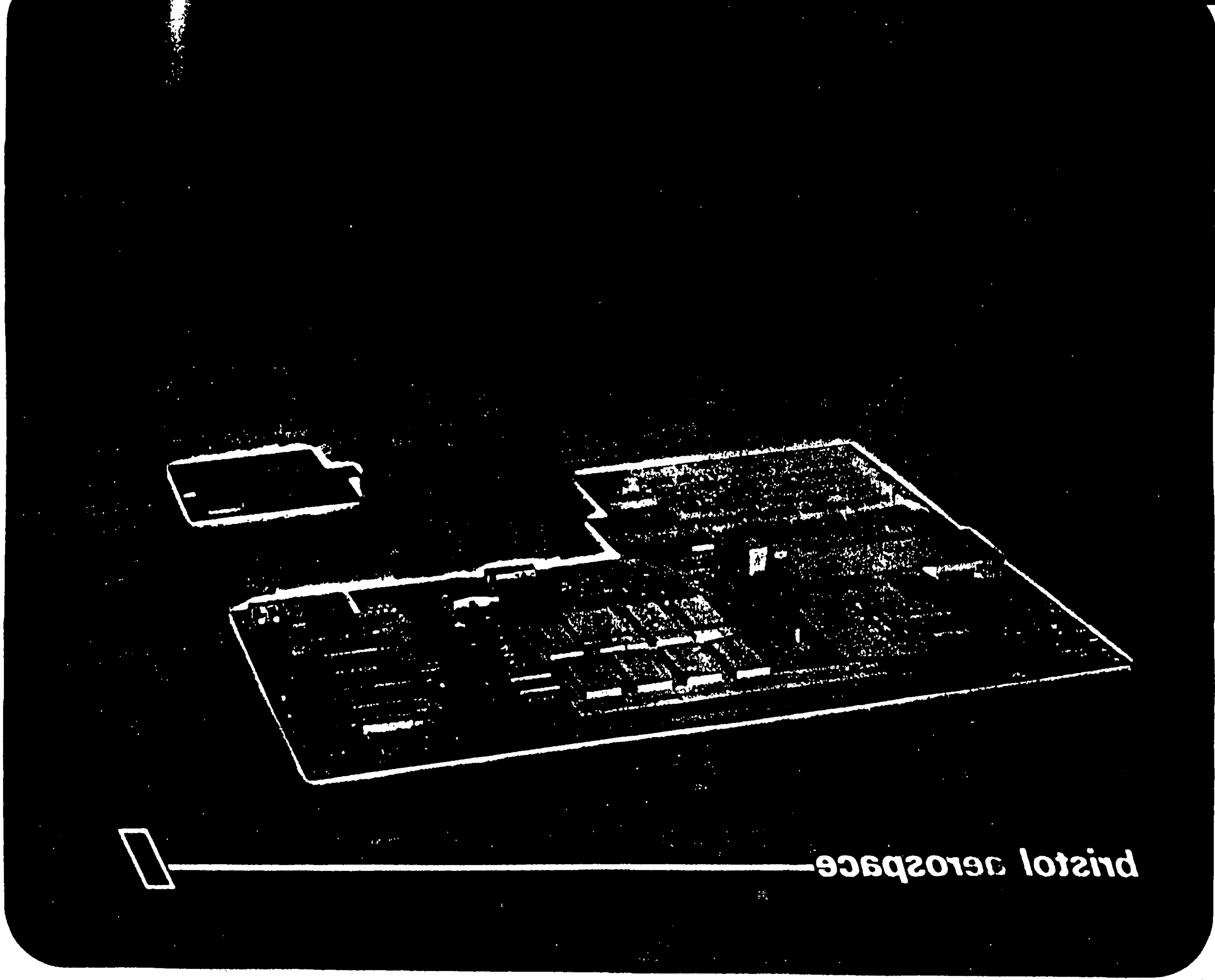
- PROCESSING FACILITY FOR SMALL UNIVERSITY, NASA CCDS, OR COMMERCIAL PAYLOADS (FOR SOUNDING ROCKETS, ORBITAL ELVs, AND SPACE SHUTTLES)
- TESTBED FOR ADVANCED LAUNCH CONTROL SYSTEMS
- LOCATED ADJACENT TO KENNEDY SPACE CENTER, AND MANAGED BY SPACEPORT AUTHORITY
- INCUBATOR CAPACITY FOR SMALL AND ENTREPRENEUTIAL FIRMS
- LABORATORY AND TEACHING FACILITY FOR SPACE SCIENCES AND ENGINEERING
- FULLY EQUIPPED FOR PAYLOAD OPERATIONS

Presentation to the NASA Workshop on the Suborbital Science Sounding Rocket Program

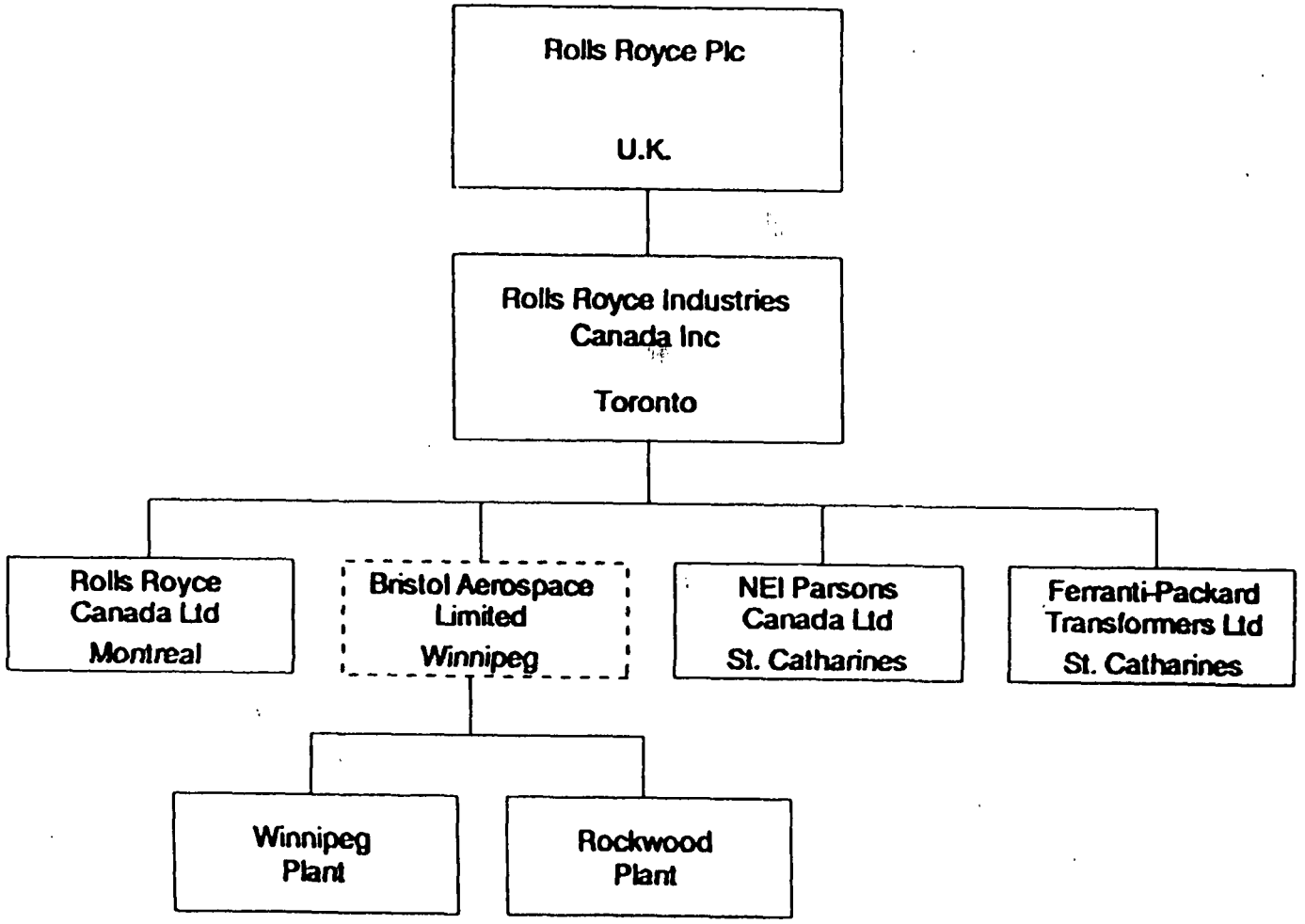
November 12,1991

Bristol Today

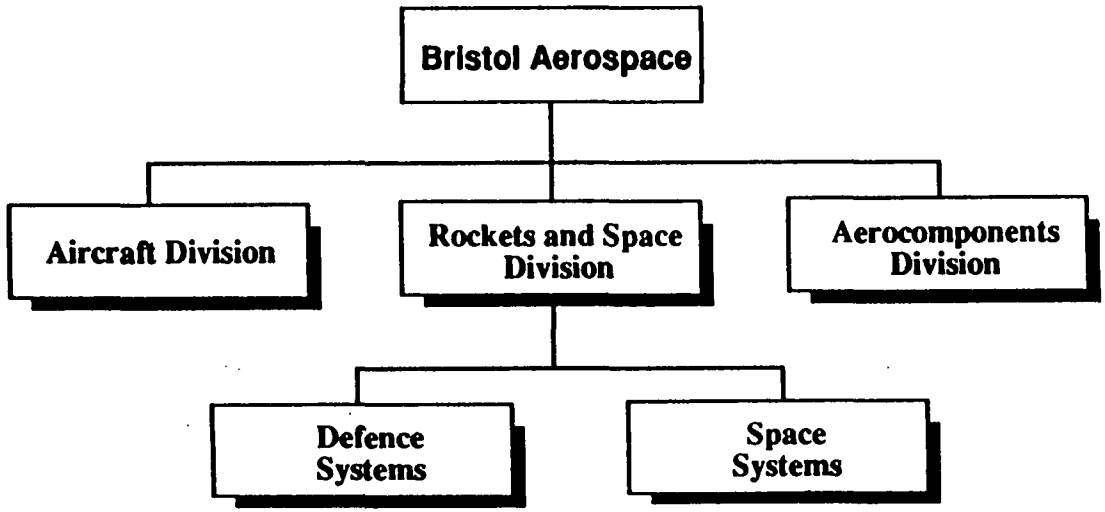
- 1,650 employees
- $150 million in annual sales
- 700,000 square feet of plant space
- Propellant plant and test facility on 4,000 acres
- Over 10 million lb of composite propellant processed



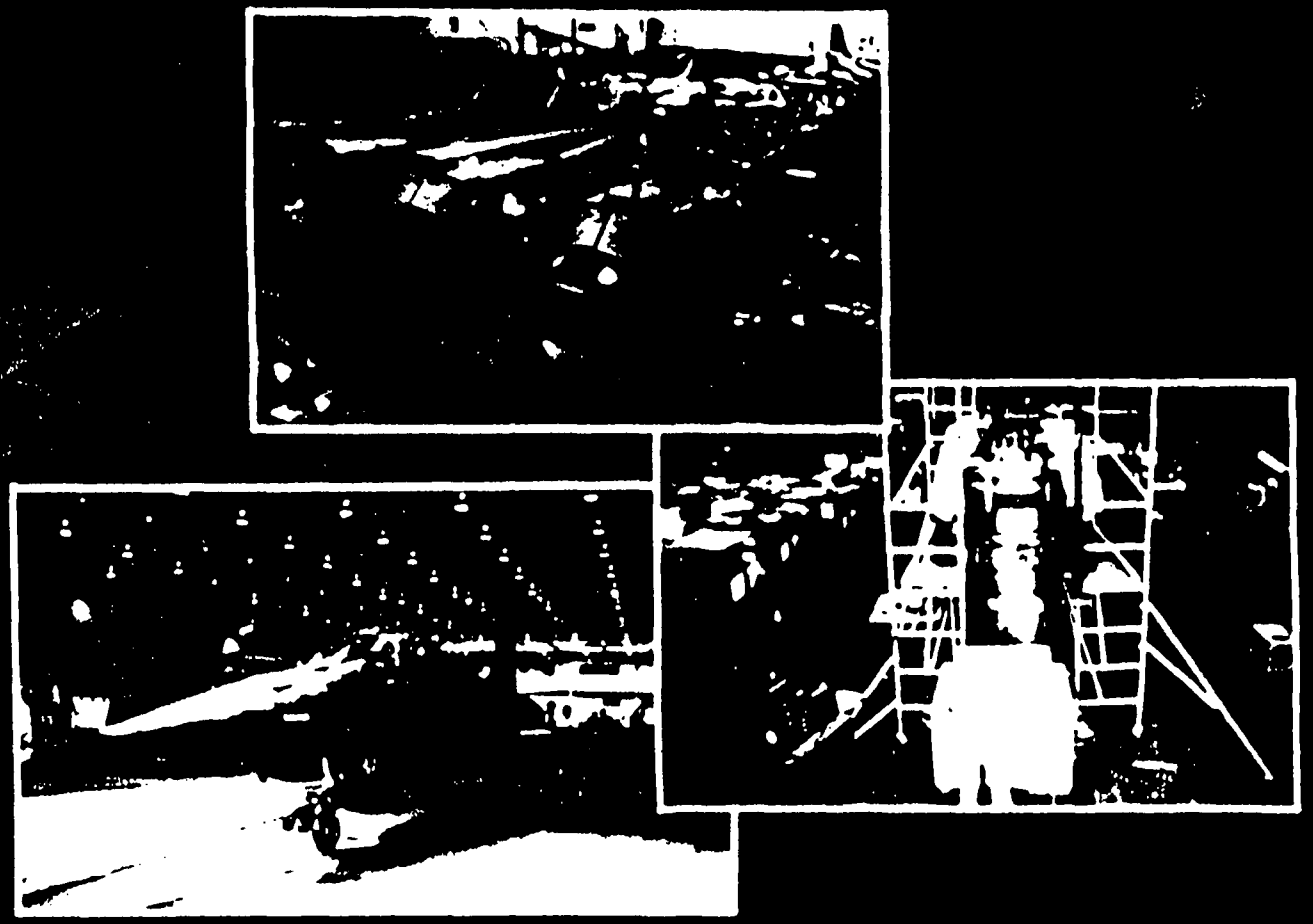
Corporate Organization



Product Groups



R&O



bristol aerospace

WSPS

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NASA Sounding Rocket Workshop
November 12,1991

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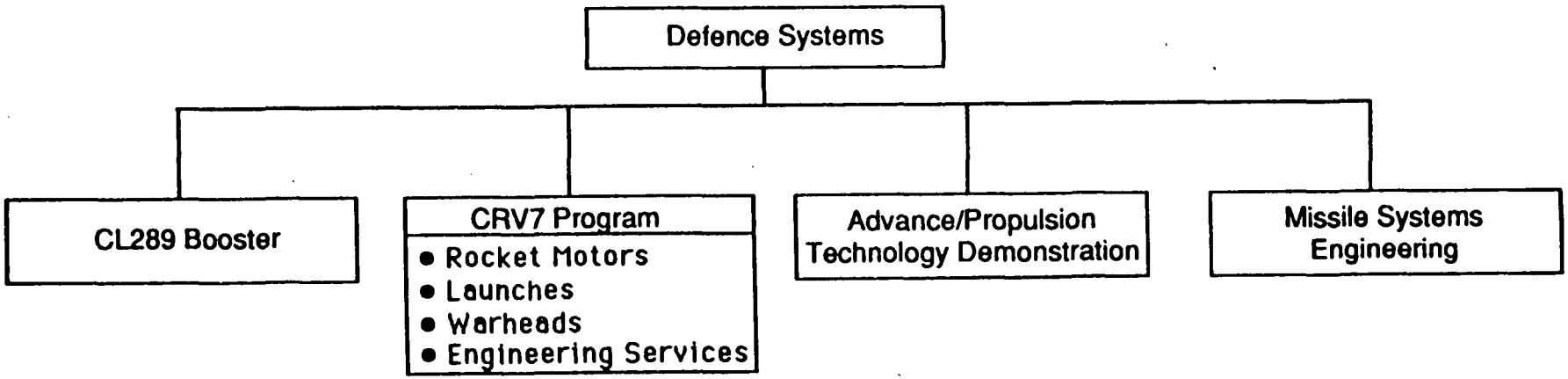
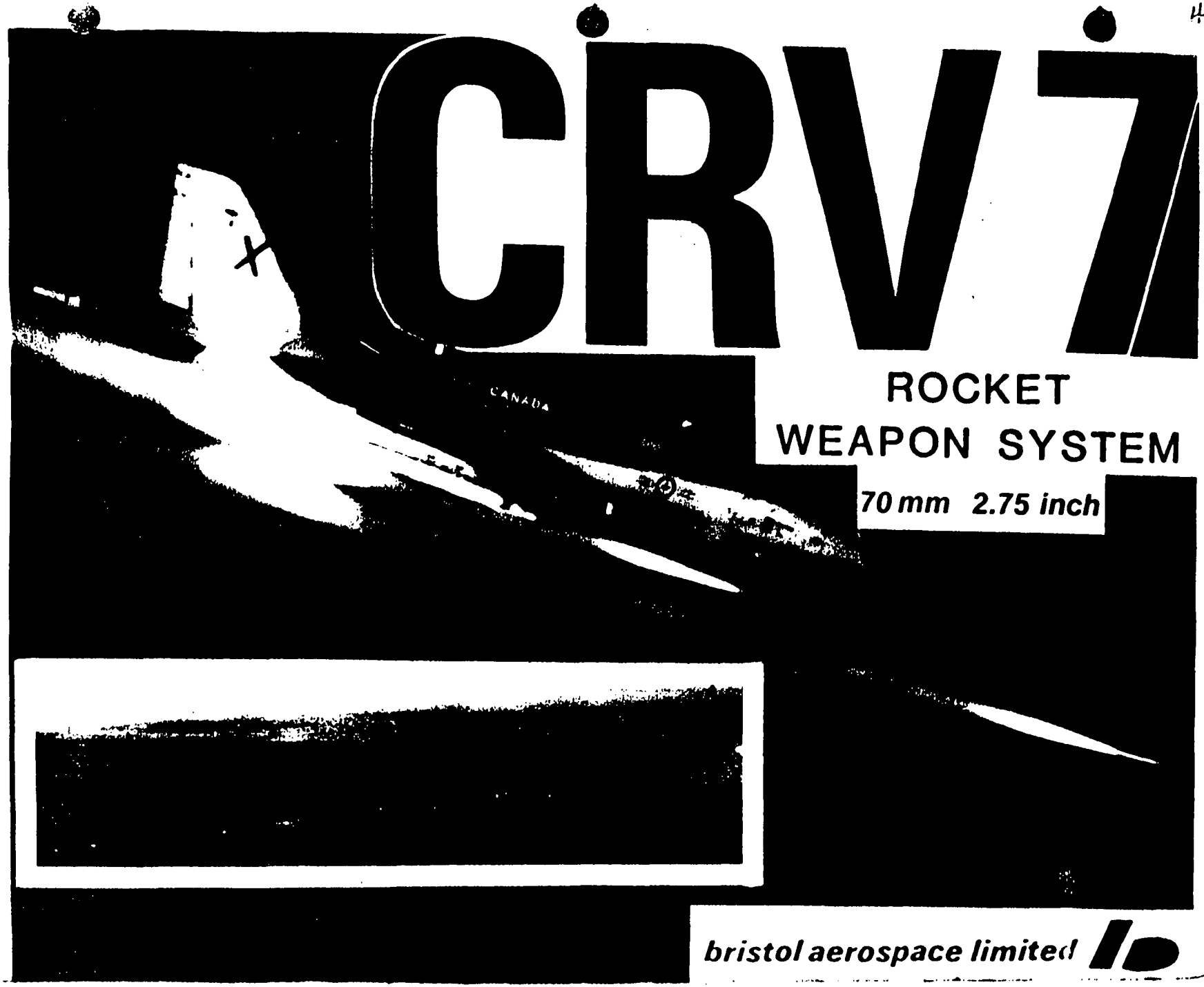
Rockets and Space Divisio



CRV7

ROCKET WEAPON SYSTEM

70 mm 2.75 inch



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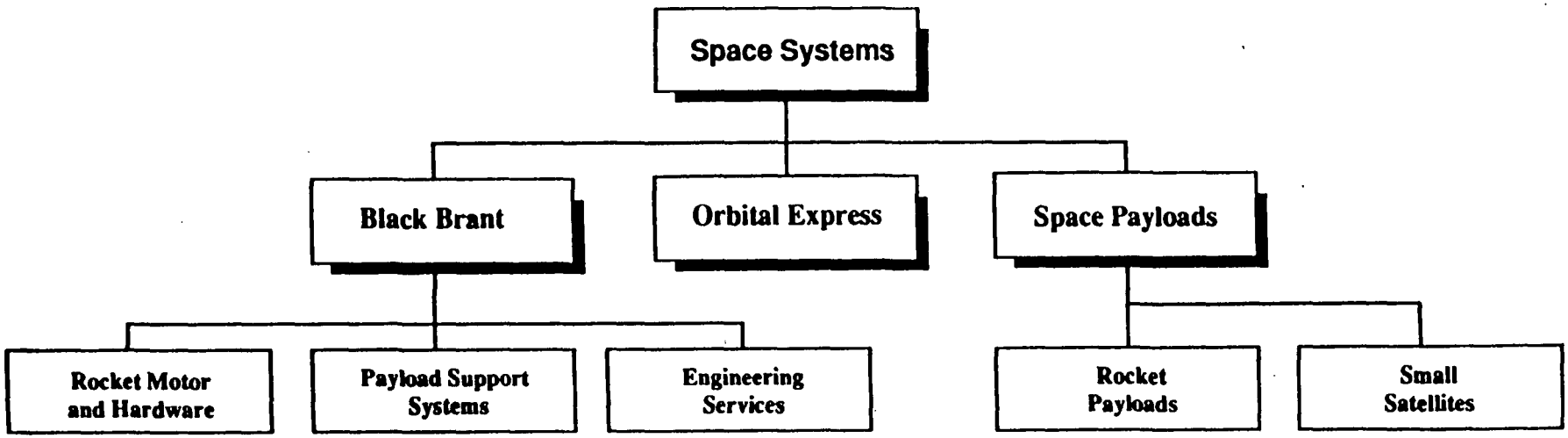
ILFORD CIBACOPY™ OVERHEAD TRANSPARENCY

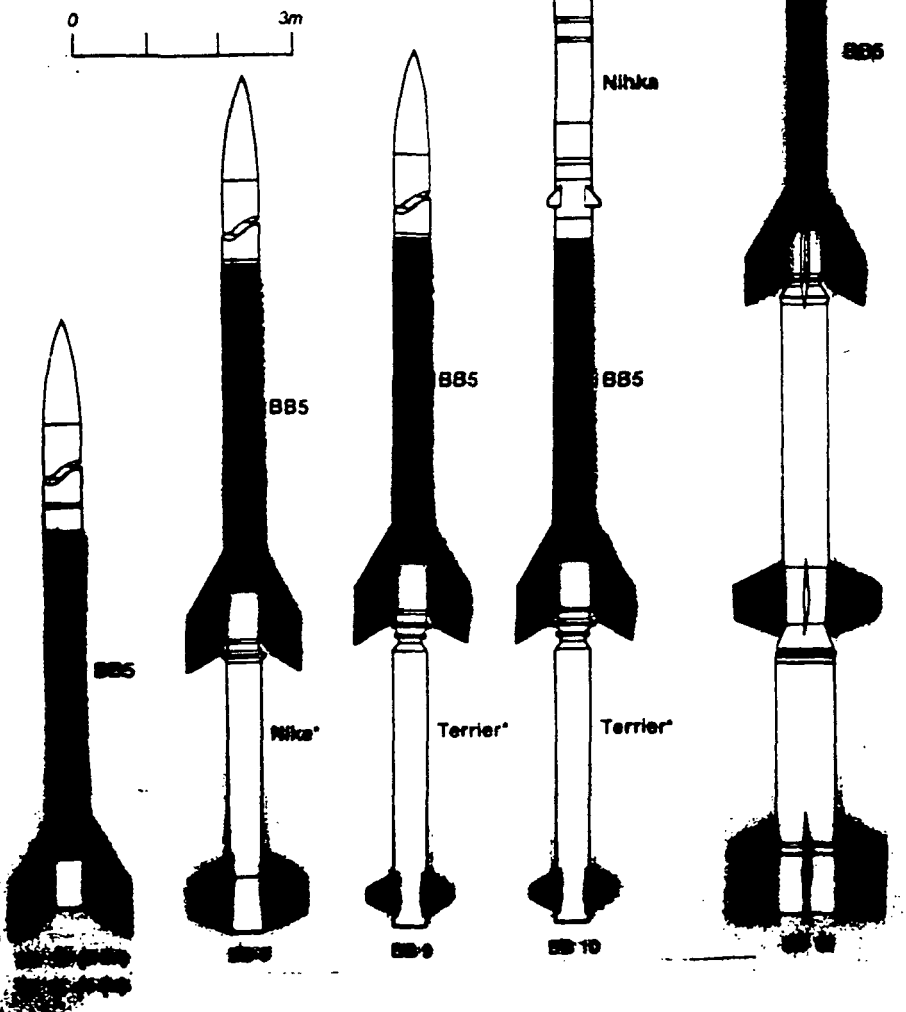
NASA Sounding Rocket Workshop
November 12,1991

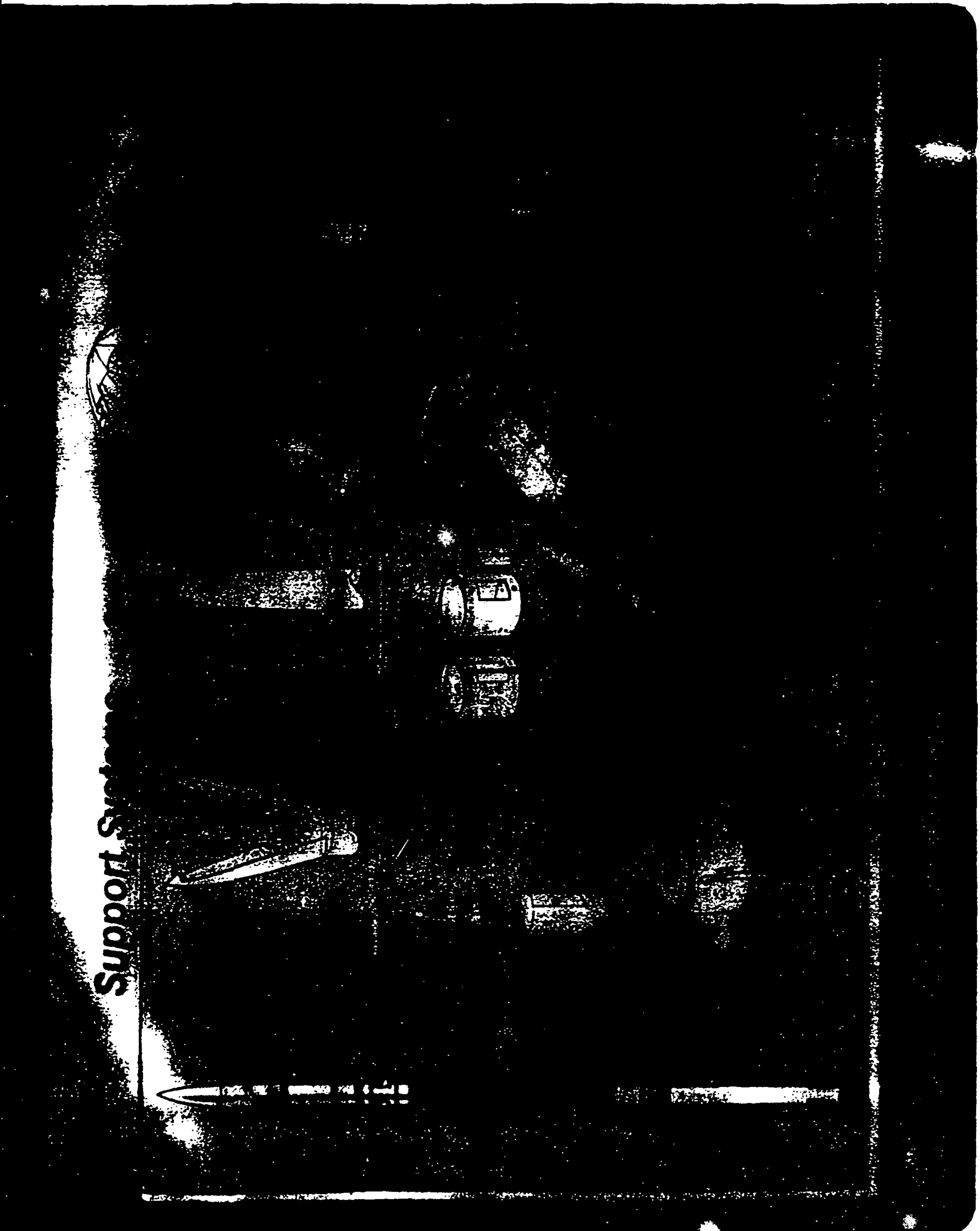
bristol aerospace
Rockets and Space Division

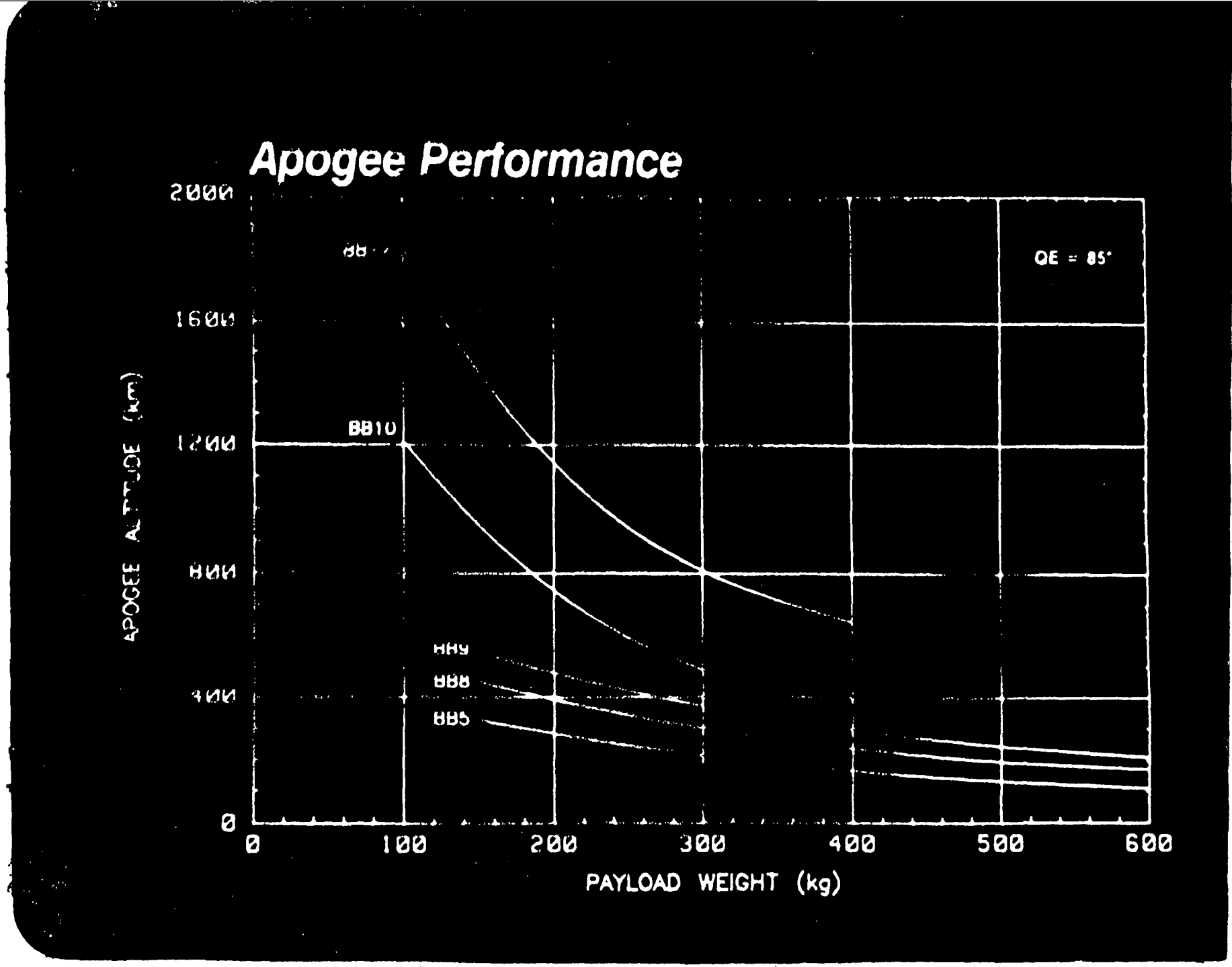


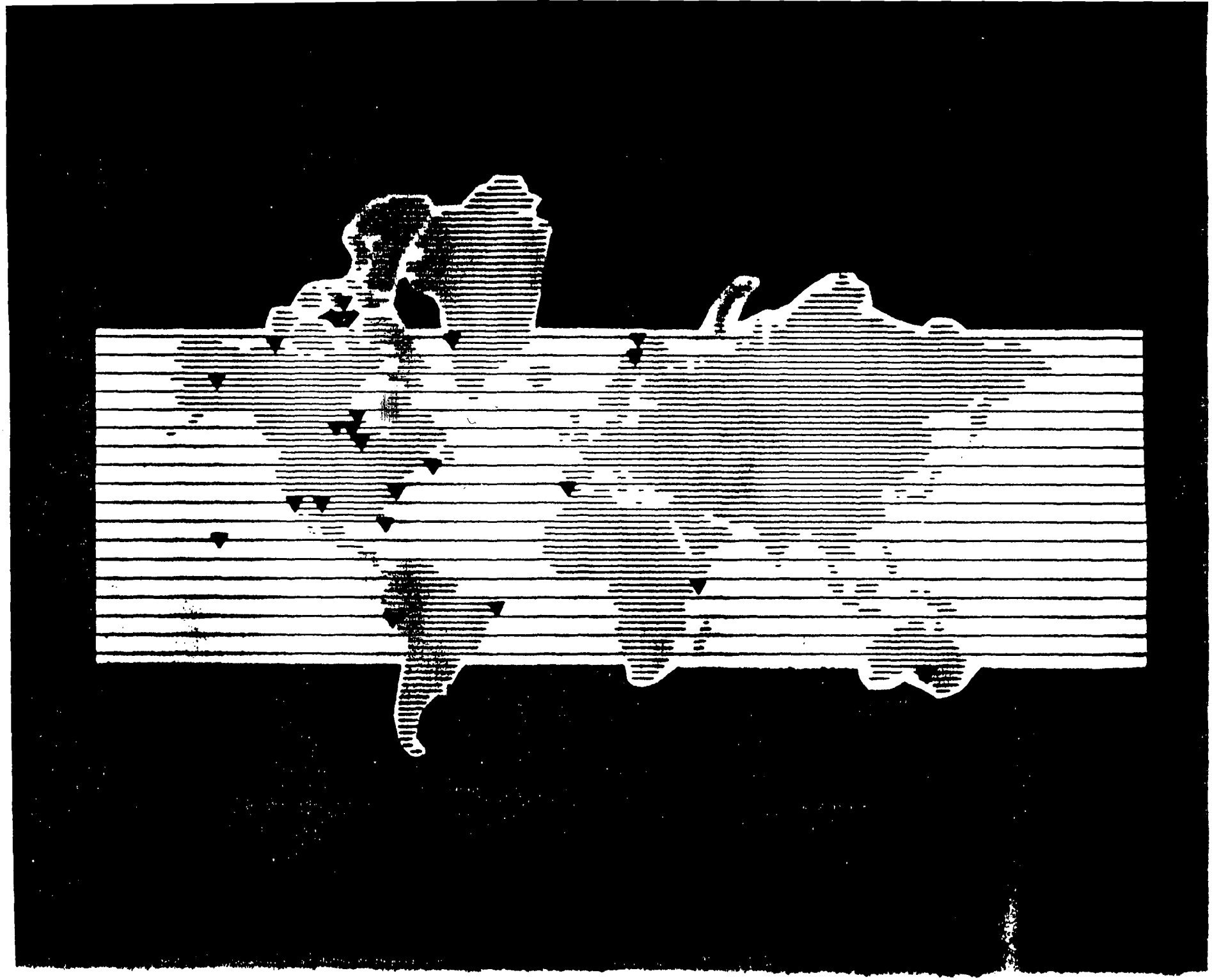
Black Brant Sounding Rockets

The Black Brant family of 44-cm-diameter (17-in.) sounding rockets, shown here with the new BB 12 — a 4-stage high-performance vehicle currently under development. Bristol also manufactures a complete line of smaller-diameter single-stage sounding rockets for carrying lighter payloads to altitudes of up to 250 km.









Black Brant Chronology

1960	BB3,BB4 and BB5 development started
1962	First launch of a Black Brant
1966	BB4 and BB5 operational
1976	BB8 operational
1981	BB10 operational
1982	BB9 operational
1989	BB11 and BB12 operational

Black Brant Users

NASA
National Research Council of Canada
Air Force Geophysical Lab
Naval Research Lab
Defense Nuclear Agency
German Space Agency(DARA)
Swedish Space Corporation
Strategic Defense Initiative Organization
MBB/ERNO
EER(Space Services Division)
Aerospatiale
Matra Marconi Space

Operational Flights of Black Brant Vehicles (as of May 23,1991)

	BB5	BB8	BB9	BB10	BB11	BB12	Total
Flights	132	98	72	31	1	2	336
Reliability(%)	97.0	99.0	100	92.9	100	100	97.9

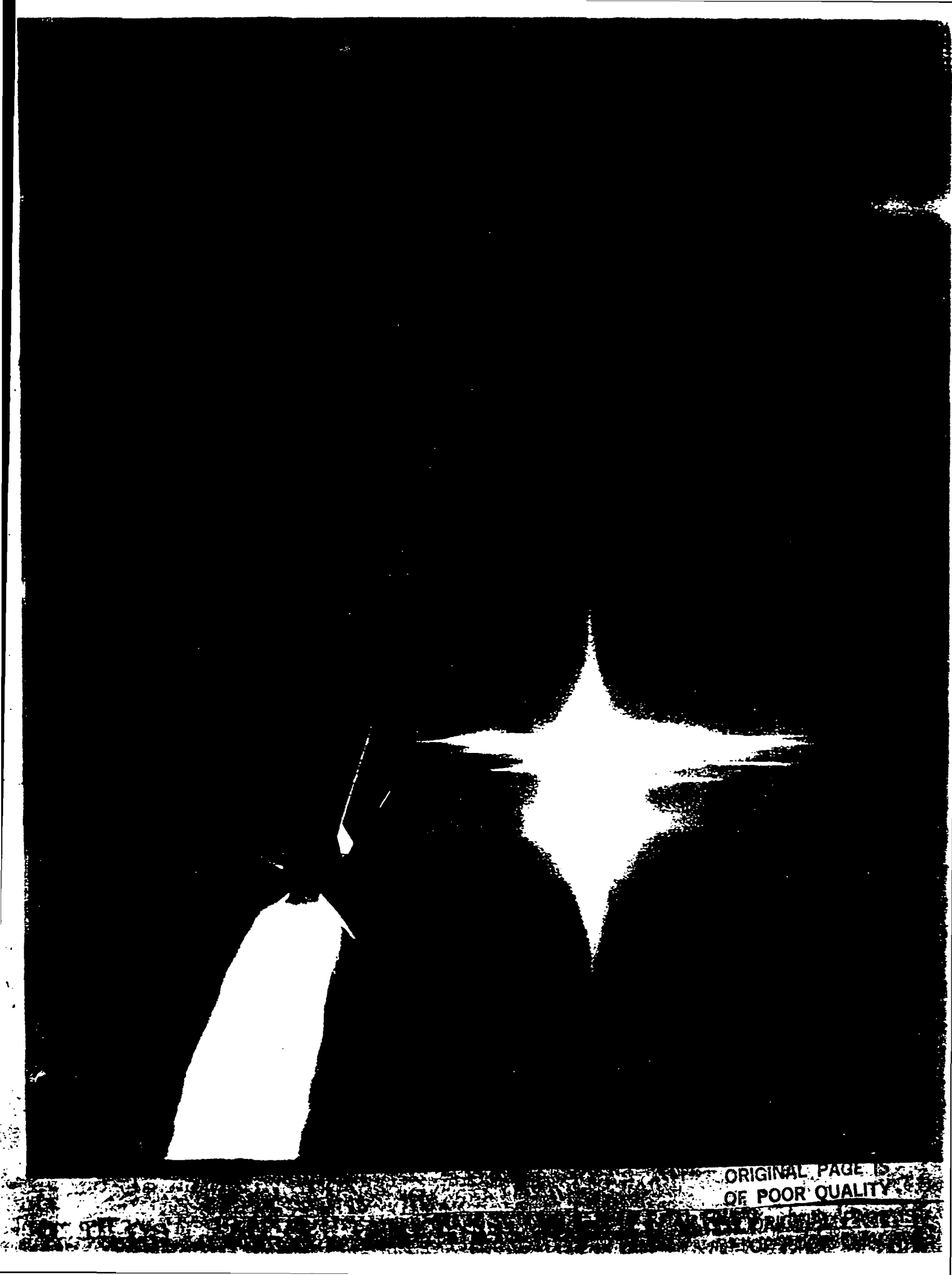
(Note:Including BB3 and BB4 there have been over 500 launches with a total reliability of greater than 98%)

Space Payload Experience

- Over 120 instrumented payloads designed and integrated
- Accumulated experience of current staff of over 300 man years
- Over 180,000 lbs of payload into space(equivalent of 3 shuttle loads)
- Over $2 million in small science satellite feasibility studies and concept designs.

The Orbital Express

- A new vehicle for launching micro and small satellites.
- Payload capacity of 200lb to 400nm circular polar orbit.
- Industry team of International Microspace,Bristol Aerospace,Thiokol Corporation and Saab Space
- First launch planned for second half of 1993.
- Privately financed.
- Complete launch service price of $4.5million.



Program and Procurement Requirements

- Bristol is a provider of vehicle hardware and engineering services, and does not intend to offer launch services.

- Bristol is a supplier of goods and services to both NASA and DOD, and has found the procurement process to be acceptable.

- For commercially manufactured hardware,multiple procurements are better for the OSSA than single because:
  1. Manufacturing lead times are 18 months.
  2. Significant cost efficiencies are achieved through larger batch sizes, reduced set-up times,and economic order quantities for materials.
  3. Contracting overhead costs are minimized.
  4. Multiple procurements allow plant load and workforce stability,hence better cost estimates and process control.

Program and Procurement Requirements(cont'd)

- Supplier selection should continue to be based upon product capability and reliability,price competitiveness,quality and performance against contract requirements.

- In over 20 years of supporting the NASA Sounding Rocket Program, Bristol Aerospace has:

  1. Met or exceeded all quality requirements,and supplied NASA with a very reliable rocket.

  2. Never jeopardized a NASA launch schedule.

  3. Provided cost effective hardware and services.

  4. Invested company funds in R and D and value engineering.

  5. Stayed in production during the "lean years".

Introduction to Orbital Sciences Corporation

Presented to
NASA OSSA Suborbital Science
Sounding Rocket Workshop

Prepared by
Space Data Division
Orbital Sciences Corporation

12 November 1991

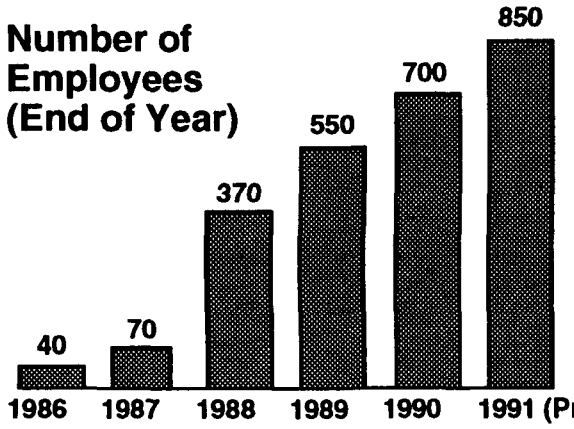
Introduction to Orbital Sciences Corporation

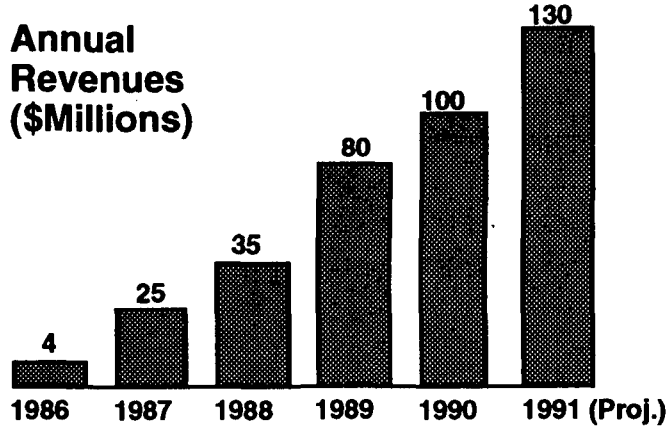
Orbital Sciences Corporation

- Market Leader in Small Space Systems
  - Over 150 Launch Vehicles and Satellites Under Contract, Representing $750 Million Order Backlog
  - 9 Launches Conducted in 1990; 18 Launches Planned in 1991; Over 25 Launches Scheduled for 1992
- Technology Innovator and Low-Cost Producer in Small Space Systems
  - Suborbital and Space Launch Vehicles
  - Orbit Transfer Vehicles
  - Spacecraft Systems and Payloads
  - Satellite-Based Communications and Remote Sensing Services
- Strong Industrial and Financial Capabilities
  - Over 800 People on Staff, Including 475 Engineers and Scientists
  - Over 350,000 Square Feet of Engineering, Manufacturing and Administrative Facilities
  - Approximately $130 Million in Projected 1991 Sales; $135M in Total Assets

Orbital's Manpower, Facilities and Financial Growth

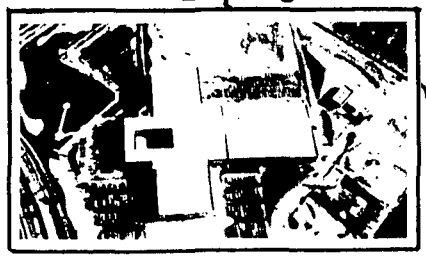
Orbital *Sciences* Corporation





R&D Laboratory
Boulder, CO

Corporate Headquarters
Fairfax, VA



Manufacturing and Test Facilities
Chandler, AZ

TM8421.PP

Orbital's Organization and Management Team

Orbital Sciences Corporation

Outside Members
Board of Directors

Fred C. Alcorn
Kelly H. Burke
Daniel J. Fink
Jack L. Kerrebrock*
J. Paul Kinloch

Outside Members
Board of Directors (cont'd)

Douglas S. Luke
John L. McLucas*
Thomas O. Paine
Harrison H. Schmitt
Richard J. Schwartz

President and CEO
David W. Thompson

Executive VP and COO
Bruce W. Ferguson

VP/Finance and
Administration and CFO
Carlton B. Crenshaw

VP and General Counsel
Leslie C. Seeman

Corporate VP & President/
Space Systems Division
Robert R. Lovell

Division EVP
John H. Mehoves

Space Launch Vehicles
Orbital Transfer Vehicles
Spacecraft Systems

Corporate VP & President/
Space Data Division
Scott L. Webster

Division EVP
Donald W. Tutwiler

Suborbital Launch Vehicles
Space Payloads and Experiments
Satellite Tracking Systems
Meteorological Products

Corporate VP & President/
Satellite Services Division
Alan L. Parker

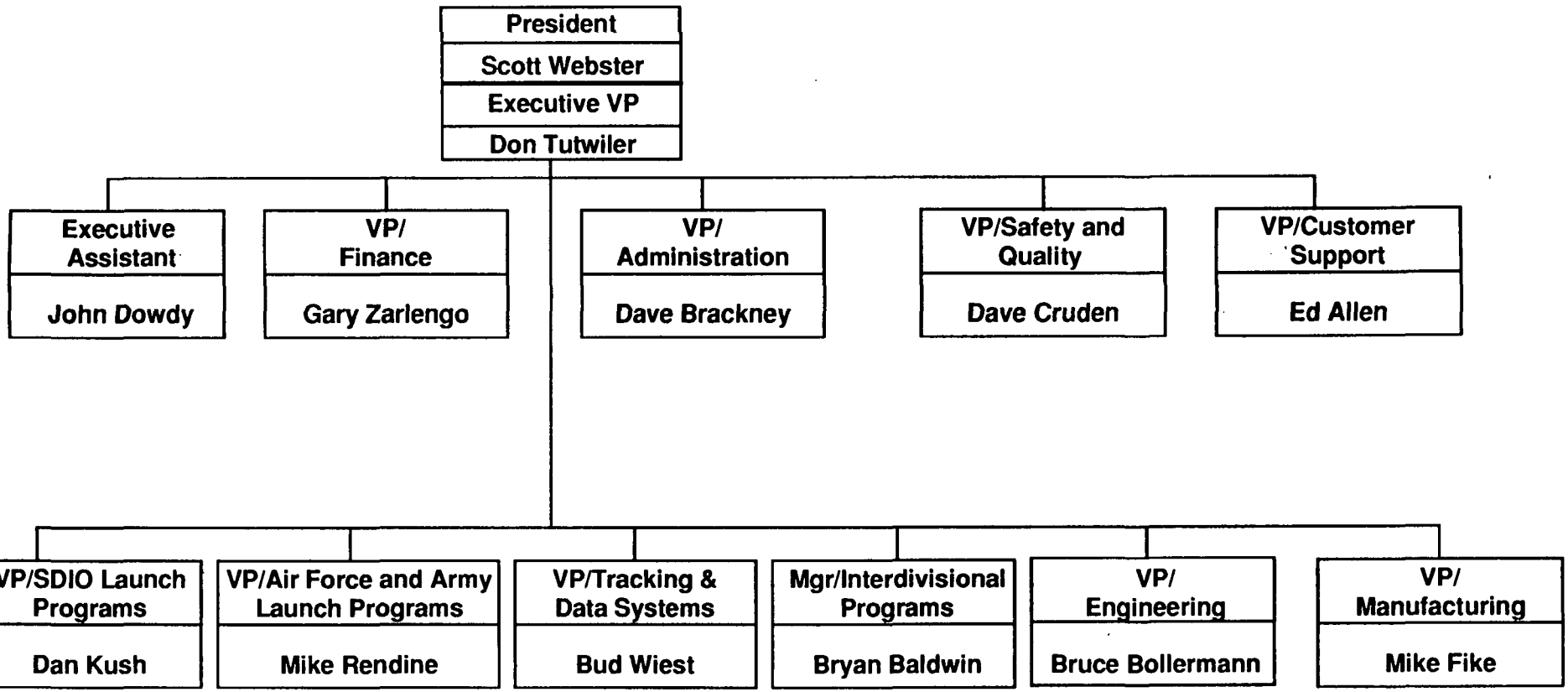
Satellite Communications Services
Environmental Monitoring Services

*Subsidiary Board (Orbital Research Corporation)

Space Data Division Organization

Orbital Sciences Corporation

Space Data Division



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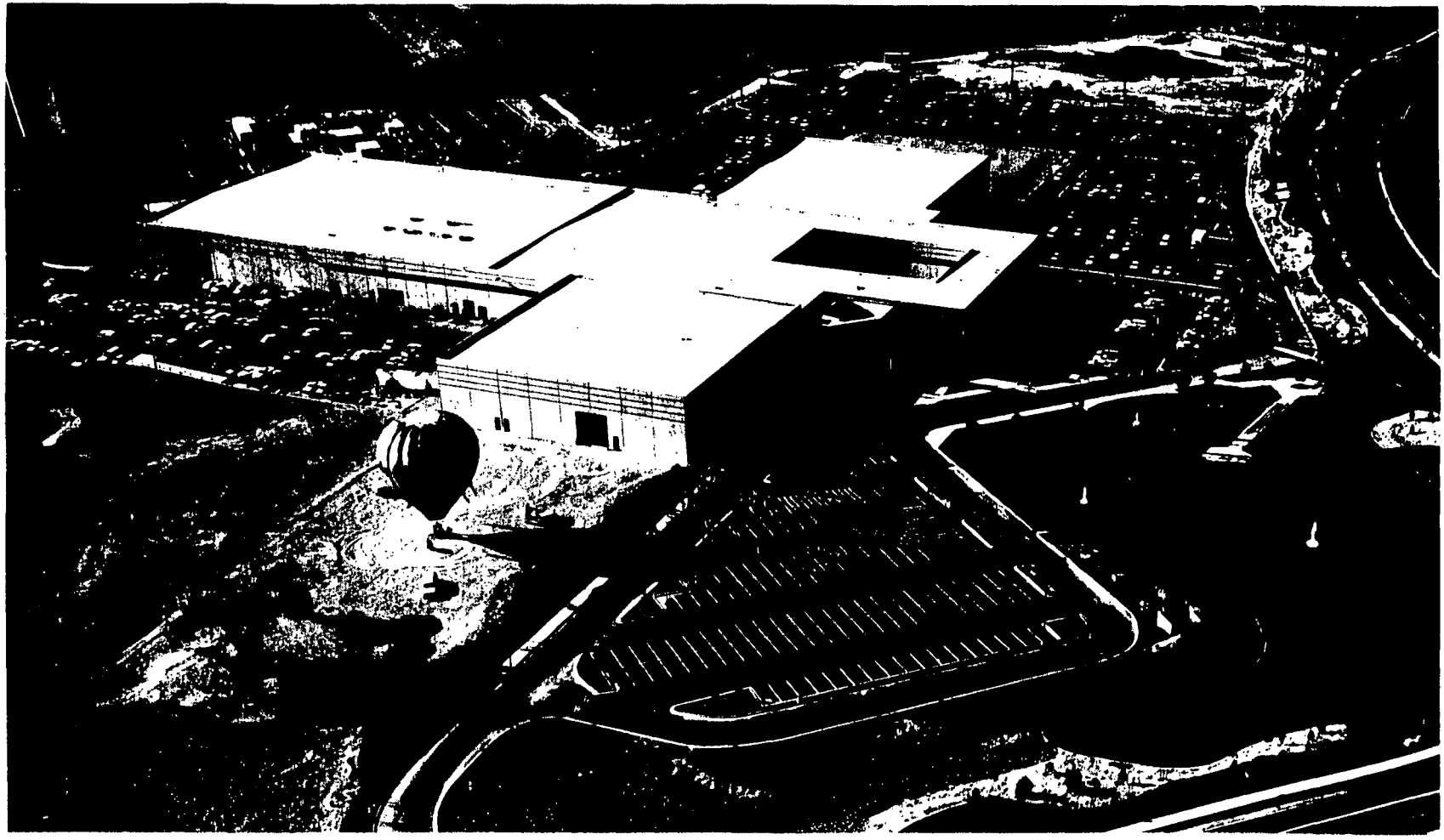
Chandler Facility

Orbital Sciences Corporation



Space Data-Products and Services

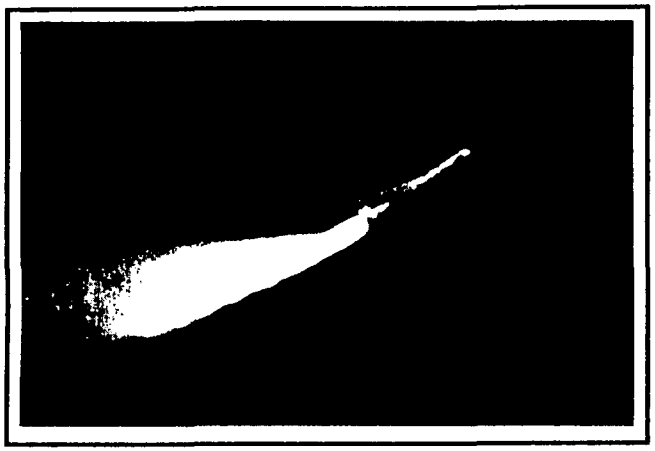
Orbital Sciences Corporaton

OSC

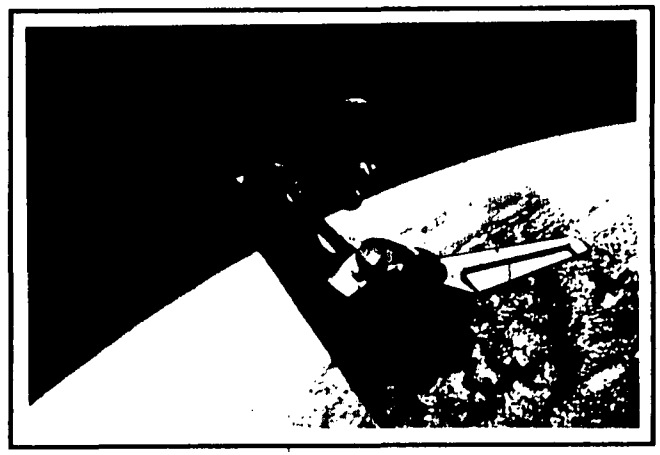
- Launch Vehicles/Services
  - Unguided
  - Program Guided
  - Inertially Guided
- Payloads
  - Bus
  - Payload Support System
  - Payload Integration
- Support Equipment
  - Launchers
  - Vehicle Handling Equipment
- Tracking and Telemetry Products
- Meteorological Products

Space Transportation Systems

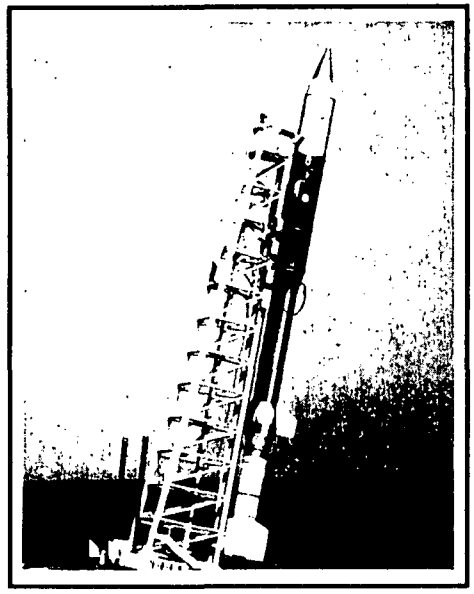
Orbital Sciences Corporation



Space Launch Vehicles



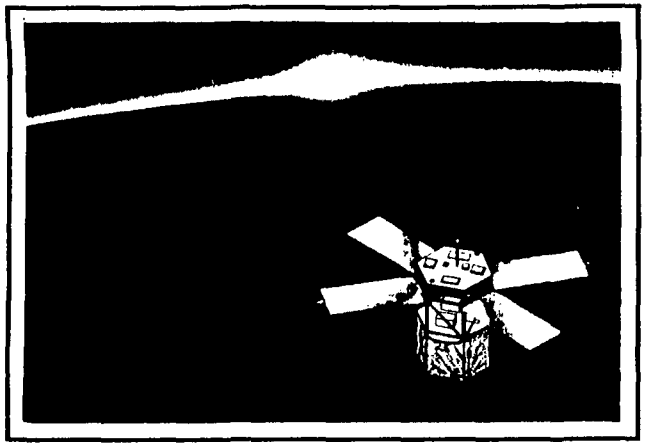
Orbit Transfer Vehicles



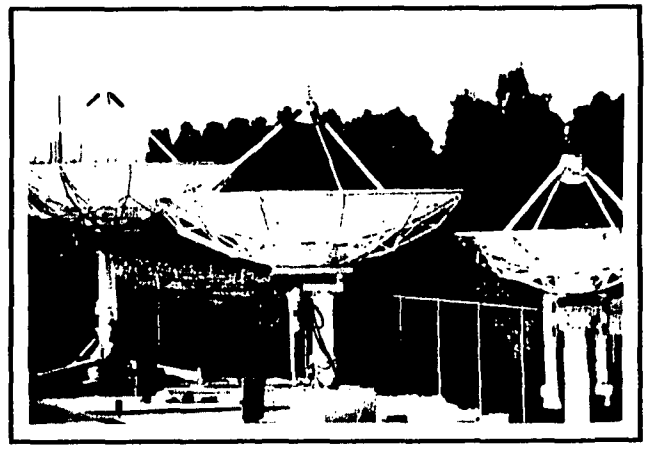
Suborbital Launch Vehicles

Spacecraft and Space Support Systems

Orbital Sciences Corporation



Spacecraft Systems



Space Support Products

Space Payloads

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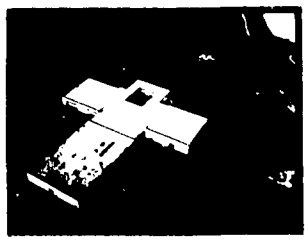
Turn-Key Suborbital Launch Services and Support Systems

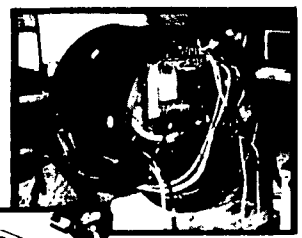
Orbital Sciences Corporation

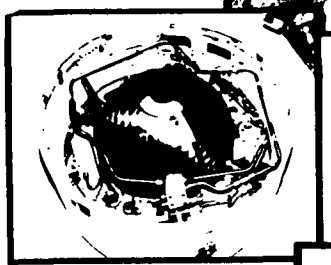
Complete vehicle design and analysis



Low-cost fabrication and component assembly

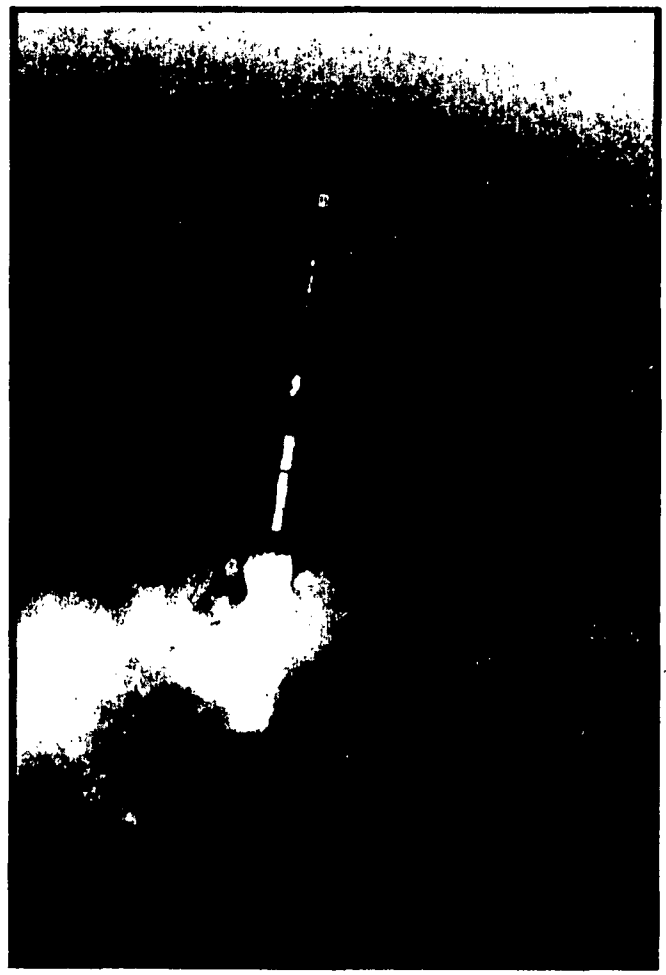
Proven final assembly and test





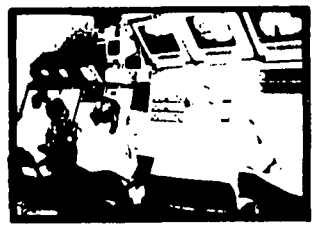
Demonstrated instrument and payload integration

Worldwide launch operations



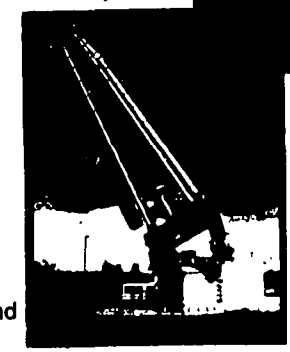
Reliable payload recovery systems

Complete range support systems



Versatile tracking and data collection systems

Modular payload and mission support systems



State-of-the art launchers and ground support equipment

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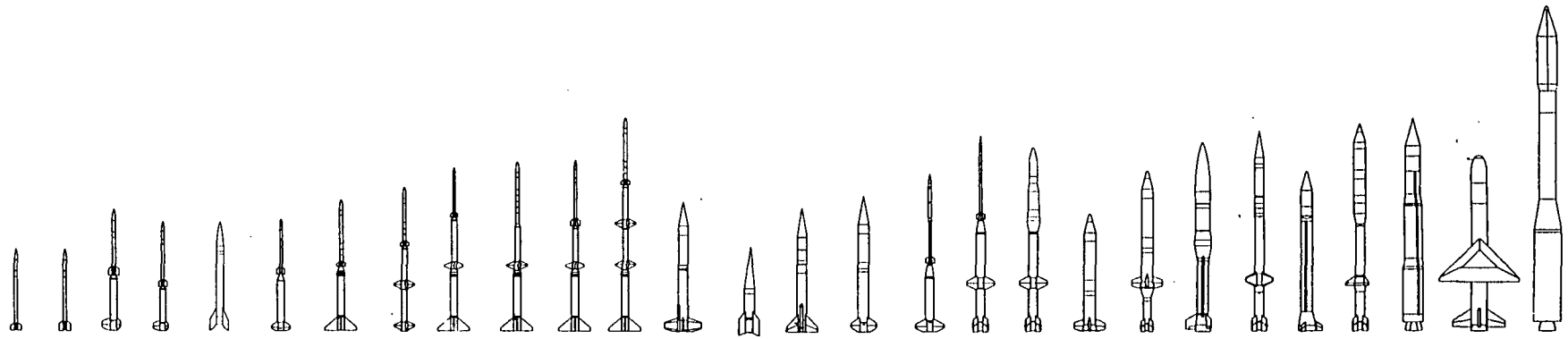
Representative Space Data-Produced Launch Vehicles

Orbital Sciences Corporation

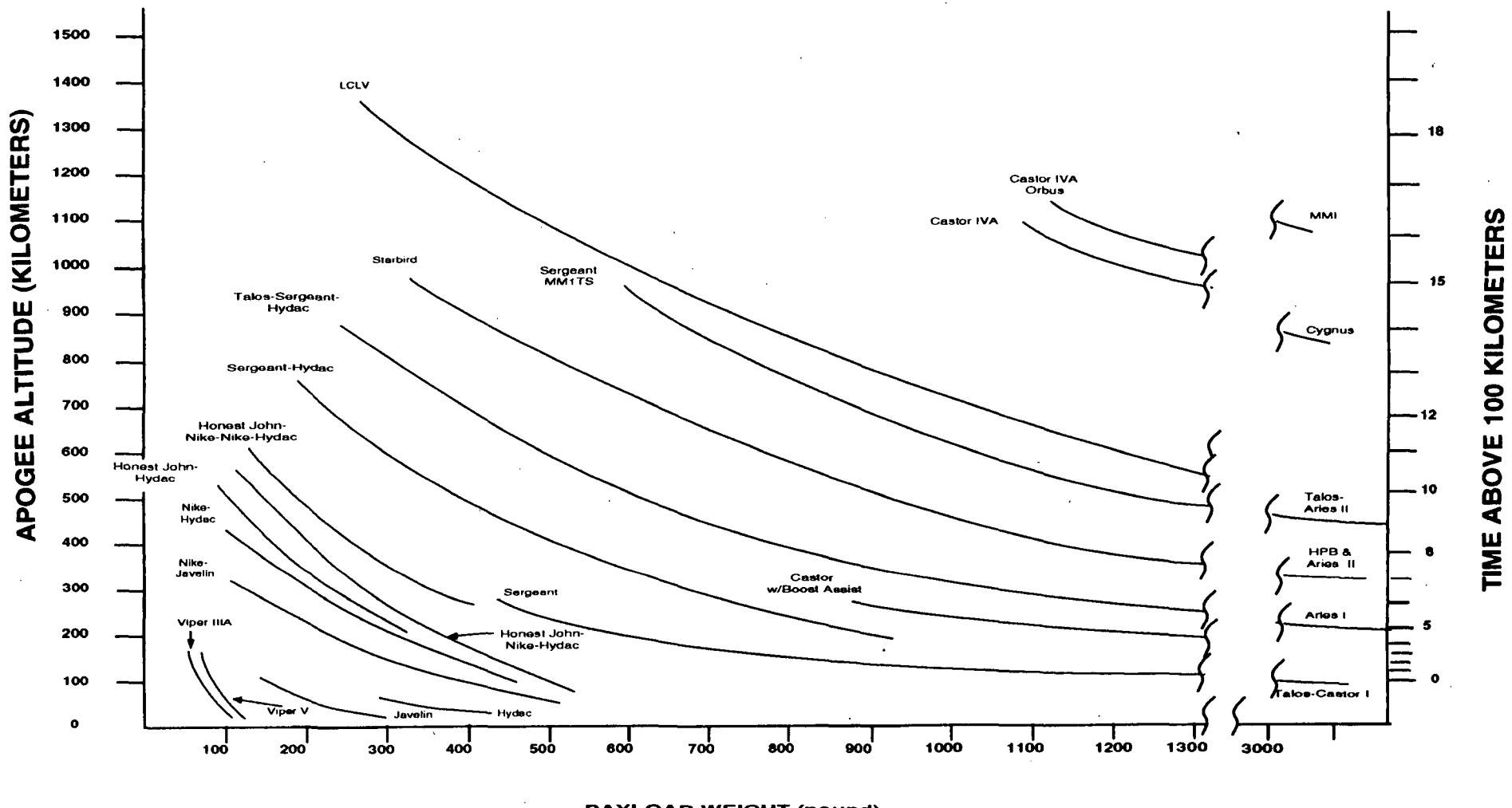


Vehicle	Javelin	Hydac	Nike-Javelin	Nike-Hydac	Black Brant VC	Improved Honest John-Javelin	Honest John-Hydac	Nike-Nike	Honest John Nike javelin	Honest John-Nike	Honest John-Nike-Hydac	Honest John-Nike-Nike-Hydac	Castor 1 Boost Assisted	Pedro	Sgt with Boost Assist	Sergeant	Sgt-Hydac	Talos-Sgt-Hydac	Talos-Sgt-M57A1 (LCLV)	Aries	Talos-Aries (HPB)	Sgt-M57A1 (ERINT/ ETS)	Talos-Castor	Castor IVA (Prospector)	Starbird	Minuteman I	Pegasus	Taurus
Category	Sub-orbital	Sub-orbital	Sub-orbital	Sub-orbital	Sub-orbital	Sub-orbital	Sub-orbital	Sub-orbital	Sub-orbital	Sub-orbital	Sub-orbital	Sub-orbital	Sub-orbital	Sub-orbital	Sub-orbital	Sub-orbital	Sub-orbital	Sub-orbital	Sub-orbital	Sub-orbital	Sub-orbital	Sub-orbital	Sub-orbital	Sub-orbital	Sub-orbital	Sub-orbital	Orbital	Orbital
Height (in)	180	216	324	360	355	360	444	468	528	564	564	708	444	360	396	402	545	680	650	460	565	521	665	557	689	718	590	1100
Liftoff Weight (lb)	550	700	1,900	2,100	3,000	3,800	5,700	3,100	6,100	6,000	6,300	7,600	12,600	4,800	10,500	9,000	10,500	13,500	15,300	16,000	20,000	15,530	18,000	27,000	16,400	69,500	41,500	150,000
Typical Gross Payload Weight (lb)	160	200	240	360	440	300	300	570	275	600	280	200	2,400	800	2,000	1,800	340	700	1,200	2,000	3,000	2,988	4,000	1,440	900	2,100+	600	3,400
Payload Dia (in.)	7-9	9	7-12	9-12	18	9-12	9-12	12	9-12	12	9-12	9	32-36	30	32	17-32	9-18	9-18	32	20-48	20-48	40	32-36	40	40	32	50	58
Apogee ($X10^6$ ft)	.12	.22	.42	.42	.88	.58	.65	.14	.78	.20	.80	1.2	525	---	.34	.34	1.8	1.3	1.9	1.1	1.1	.58	0.6	2.6	1.1	4.0+	---	---
Apogee Sensitivity (Kft/10 lbm))	6.7	8.2	16.4	16.4	28.7	16.4	16.4	1.5	8.4	1.5	27.3	41	2.2	---	1.6	6.6	30.0	50.0	16.7	4.5	5.0	2.3	2.0	12.0	12.0	---	---	---
Launch System	Rail	Rail	Rail	Rail	Rail	Rail	Rail	Rail	Rail	Rail	Rail	Rail	Rail	Aircraft (F-4)	Rail	Rail	Rail	Rail	Rail	Rail/ Stool	Rail/ Stool	Rail/ Stool	Rail	Stool	Rail	Stool	Aircraft (B-52)	Stool
Programs/ Customers	ICE-CAP/ DASA	ICE-CAP/ DASA	Energy/ DASA NRL DNA	Aurora/ BSD AFGL DNA	DASA	ICECAP/ DNA	Wide Band Aurora/ DNA	Smoke/ DASA	Secede/ DNA	Smoke/ DASA	HJIV	HJ-2/ BSD	Recovery/ DNA	FLAGE DNA	SWIR-Ballistic/ DNA	FWIR/ DNA	HAVE JEEP/ BSD	HAVE JEEP/ BSD	LCLV/ BSD	Spear II/ DNA	HPB/ AFGL	ETS USASDC	Spirit I/ AFGL	Joust/ U of A	Star-lab/ USAF	RSLP/ BSD	ASTP/ DARPA, STP/ USAF	ASTP/ DARPA Comm
Range Compatibility (A)	1,2,3,5 6,7,8,9	1,2,3,5 6,7,8,9	1,2,3,5 6,7,8,9	1,2,3,5 6,7,8,9	1,2,3,5 6,7,8,9	1,2,3,5 6,7,8,9	1,2,3,5 6,7,8,9	1,2,3,5 6,7,8,9	1,2,3,5 6,7,8,9	1,2,3,5 6,7,8,9	1,2,3,5 6,7,8,9	1,2,3,5 6,7,8,9	1,2,3,5 6,7,8,9	3,7	1,2,3,5 6,7,8,9	1,2,3,5 6,7,8,9	1,2,4-	1,2,5,6 7,8	1,2,4,5 6,7,8	All	1,2,5,6 7,8	All	1,2,5,6, 7,8	All	2,8	4	1,2,4,7,8 and Other	2,4

(A) 1=Wallops 2=ETR 3=WSMR 4=WTR 5=Poker Flat 6=Barking Sands 7=Kwajalein 8=Wake 9=Eglin

OSC Suborbital Booster Performance

Orbital Sciences Corporaton



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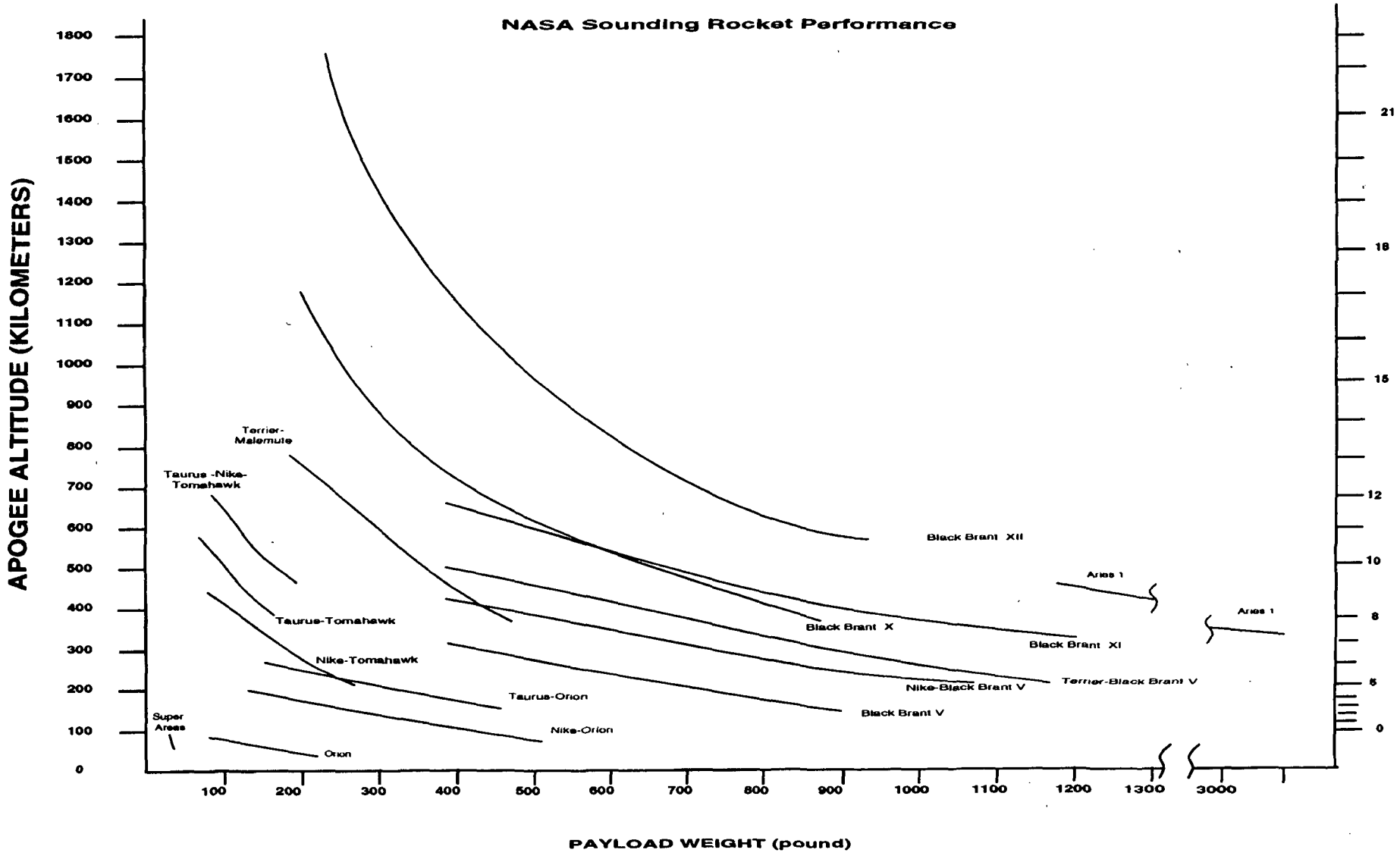

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American Rocket Company

Hybrid Rocket Propulsion for Sounding Rocket Applications

NASA OSSA

November 12, 1991

American Rocket Company

HYBRID ROCKET TECHNOLOGY

- Why Hybrid Rocket Technology ?
- HyFlyer Sounding Rocket

805-987-8970
Camarillo, CA

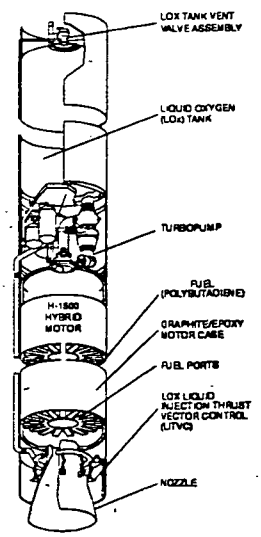
American Rocket Company

Why Hybrid Rocket Technology ?

- **Hybrid Rocket Fundamentals**
- **Hybrid Characteristics**
- **Hybrid Advantages**

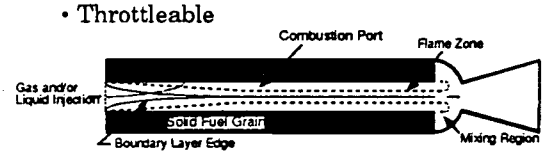
American Rocket Company

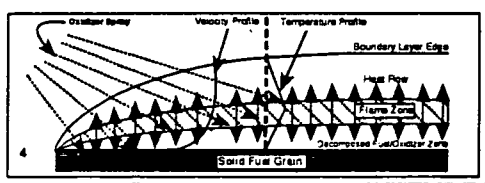
Hybrid Rocket Fundamentals



H-225K Hybrid Motor

- **Solid Hydrocarbon Fuel (e.g., PBD) and Liquid Oxidizer (e.g., LOx)**
- **Combustion Process**
  - Driven by Flow of Oxidizer over Fuel Surface)
- **Fuel/Oxidizer Separation**
  - Safe
  - Throttleable





Hybrid Characteristics

- **Safe - Cannot Explode**
  - No Intimate Mixing of Fuel and Oxidizer
  - Combustion Process is Diffusion Limited
- **Throttleable**
  - Thrust Proportional to Oxidizer Flowrate
- **Scaleable**
  - Thrust Scales with Internal Surface Area and Oxidizer Mass Flux
- **Environmentally Clean**
  - Fuel Selection and High Flame Temperature Result in Clean Exhaust Products

Hybrid Advantages

- **High Performance**
- **Low Cost Due to Fundamental Safety**
- **Low Cost Due to the Nature of Hybrids**
- **Low Risk**
- **Flexible**

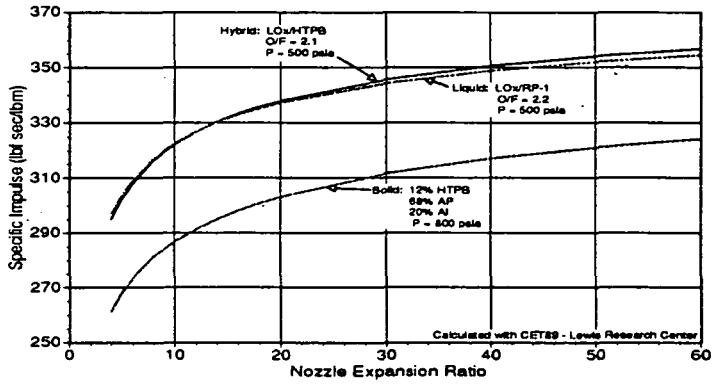
American Rocket Company - HyFlyer Sounding Rocket Program

Hybrid Advantages *American Rocket Company*

High Performance

- I_{SP} is Equivalent to LOx/Hydrocarbon Engines (e.g. Saturn V F-1 1st Stage Engine)--10-15% Higher than Solid Motors
- Throttleability Increases Payload to Orbit

IDEAL VACUUM SPECIFIC IMPULSE FOR A HYBRID, SOLID, and LIQUID ROCKET MOTOR



Hybrid Advantages *American Rocket Company*

Low Cost Due to Fundamental Safety

- Safe Technology Reduces Costs in All Phases of Development, Production and Operations
- No Remote/Automated Production Facilities Required
- Anomalous Events Do NOT Destroy Test Facilities or Launch Pads
- No Restrictions on Personnel Activity In Any Phase of Development, Production or Operations
- No Special Handling or Transportation Requirements
- Lower Insurance Costs in All Phases

American Rocket Company - HyFlyer Sounding Rocket Program

Hybrid Advantages — *American Rocket Company*

Low Cost Due to the Nature of Hybrids

- **Low Production Costs**
  - Reduced Complexity
  - Few Critial Tolerances
  - Short Production Cycle (weeks)
  - Low Production Facilities Costs

} *Standard Light Industrial Facilities Are Adequate*

- **Low Materials Costs**
  - No Strategic Materials
  - Multiple Commercial Sources
  - Many Material Options
- **Low Operations Cost**
  - Reduced Manpower Requirements
  - Reduced Inspection Requirements

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Hybrid Advantages — *American Rocket Company*

Low Risk

- **Non-Explosive Therefore No Catastrophic Detonations**
- **Command Shutdown In the Event of Problems Affords Safe Abort**
- **Safe Engine Idle Allows Engine Verification Prior to Full Thrust**
- **Insensitive to Environmental Conditions**
- **Robust Combustion Cycle**
  - Resistant to Manufacturing Defects
  - Self-Damping
- **Safety = Less Complexity = High Reliability**
- **No Uninsurable Liability**
- **No Hazardous Materials and Clean Exhaust = No Environmental Risk**

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American Rocket Company - HyFlyer Sounding Rocket Program

Hybrid Advantages *American Rocket Company*

Flexible

- **Rapid Response to Customer Requirements**
  - Simple Designs Allows Product Customization
  - Short Development Cycle (Months)
- **Facilitization**
  - Commercial Production Facilities and Short Lead Time Parts Permits Buildup of Production Capability to Match Demand
- **Surge Capability**
  - No Specialized Manufacturing Equipment
  - No Long Lead Time Items
  - No Strategic Materials

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Why Haven't Hybrids Been Used Before ?

- **Initial Difficulty in Maintaining Stable Hybrid Combustion**
- **Early Focus on "Performance At Any Cost"**
  - Designs Optimized for Maximum I_{sp}
  - Military ICBM Requirements Drove All Initial Designs
- **Initial Emphasis on Solids Based on System Readiness**
  - ICBM Requirement
- **Liquids Developed Intensively For Apollo Program**
- **Larger Database on Solids and Liquids Made Hybrids Higher Risk Option for Later Programs**
- **Large Investment in Facilities to Produce and Test Solids and Liquids Supported Predisposition to Those Technologies**

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American Rocket Company - HyFlyer Sounding Rocket Program

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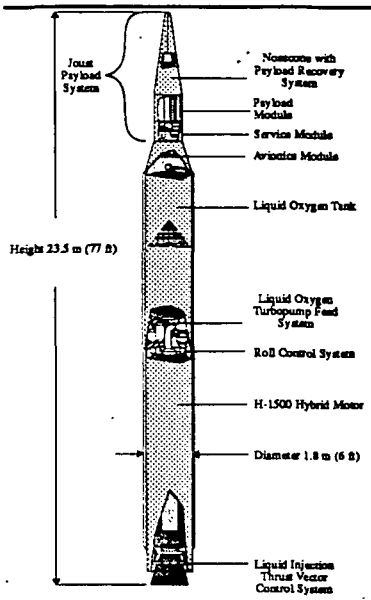
The HyFlyer Suborbital Vehicle



- Provides 11 Minutes of Microgravity Time for a Joust-class Payload
- Based on AMROC H-1500 Liquid Oxygen/Polybutadiene Hybrid Rocket Motor
- In Development to Validate H-1500 Motor for Use in Aquila Orbital Vehicle

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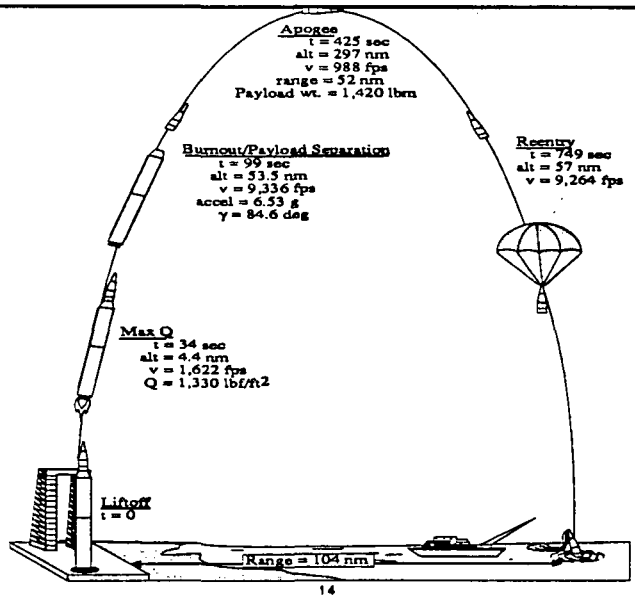
HyFlyer Mission Profile



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American Rocket Company - HyFlyer Sounding Rocket Program

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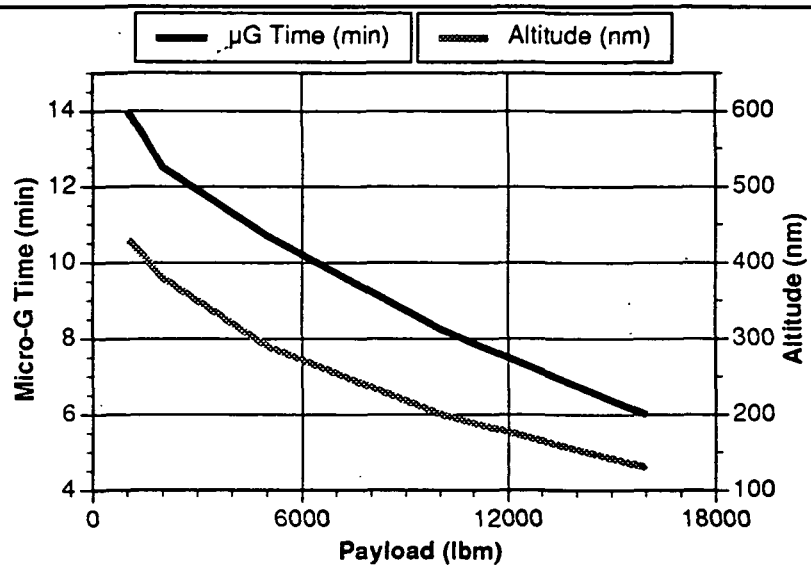
HyFlyer Performance



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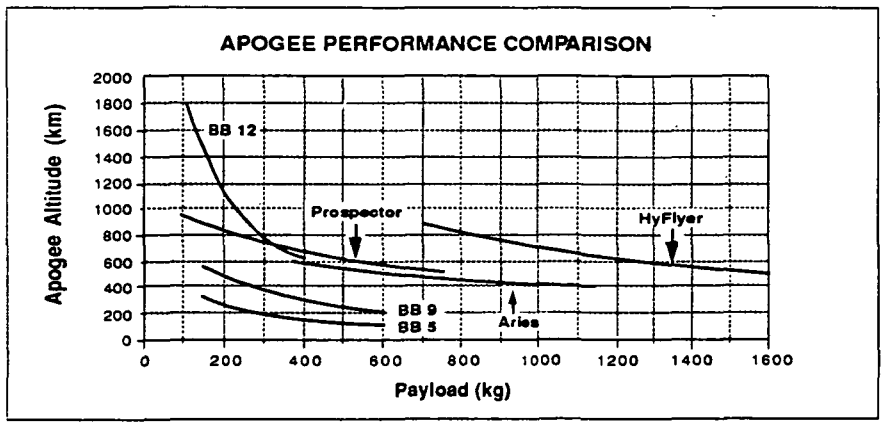
HyFlyer Comparitive Performance



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American Rocket Company - HyFlyer Sounding Rocket Program

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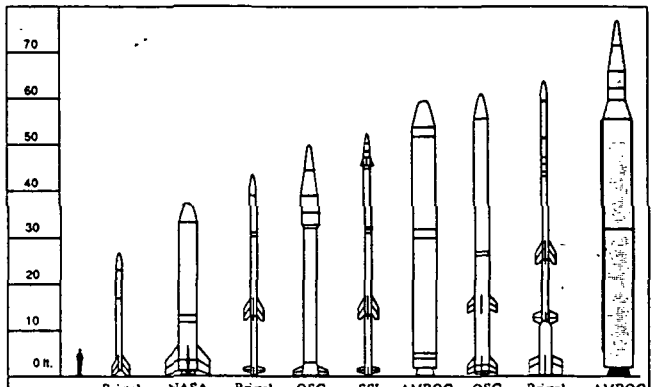
Sounding Rocket Fleet



	Bristol Black Brant VB	NASA Aries	Bristol Black Brant IX	OSC Prospector	SSI Starfire	AMROC SET-1	OSC Starbird	Bristol Black Brant XII	AMROC HyFlyer
Payload Capability (Kg.)	150 - 600	350 - 1150	150 - 600	100 - 500	150 - 600	---	200 - 2,400	100 - 400	750 - 7,270
Microgravity Time (min.)	3 - 7	8 - 11	6 - 11	12-15	6 - 11	---	6 - 24	12 - 24	6 - 14

American Rocket Company

HyFlyer Summary

- **AMROC's HyFlyer is the Mac Truck of Sounding Rockets**
  - Unique Heavy Lift Capability - 8 Tons!
- **72" Diameter Booster - Large Payload Volume Available**
- **Developed to Validate Hybrid Propulsion For AMROC's Orbital Vehicle - Aquila**
- **Available Late 1993**
- **Estimated Launch Cost ≈ $3.5M**